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POWER PLANT CHEMISTRY

Laboratory Equipment for Proximate Analysis of Coal, Its Use and Detailed Description of Analyses

IN the modern isolated power plant where the demand is made upon the engineer to cut cost of operation down to the point where power is produced cheaper than it can be purchased from the central station, as well as in the large central station where specialists are in charge of the various parts of the plant, a knowledge of what the coal contains as well as the proportions of the elements and the heat value of the coal is of prime importance.

It is customary in many plants to send samples of the coal to a chemist for analysis and the desired information is thus obtained. Having obtained an analysis of the coal the next question is, how can this knowledge be of use in the plant? It is the purpose of this and succeeding articles on the same subject to show the reader how he can make his own analysis of coal or other fuel, as it comes to the plant, at a comparatively small expense, and to point out what he may expect of his fuel with varying proportions of the elements contained.

To make a chemical analysis of a substance usually requires considerable apparatus and in many cases reagents; but for the engineer, an extensive laboratory equipment is not necessary and its cost need not be excessive.

Taking up first the proximate analysis of coal, the apparatus and prices for which it can be obtained are as follows:

Balance, accurate to 1 milligram	$12.00
Weights for balance	3.00 up
Crucibles, ½ doz., with covers, at 10c	.60
Tongs	.40
2 Burners at 50c	1.00
2 Tripods, screens and triangles	.94
Sieve, 70 mesh to the inch	1.00
Desiccator	1.50
Mortar and pestle	4.50
Total	$24.94

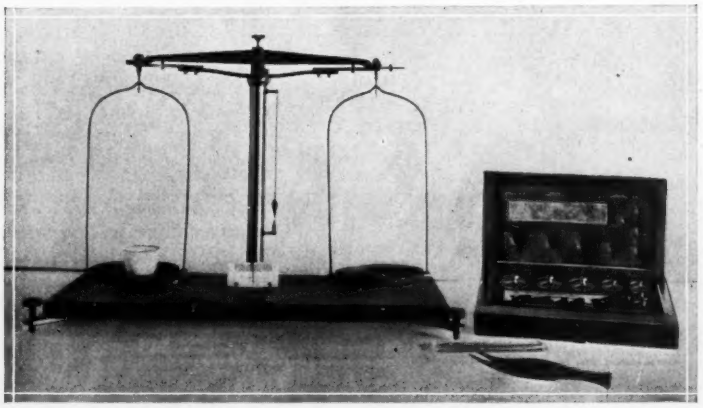

FIG. 2. CHEMICAL BALANCE AND WEIGHTS

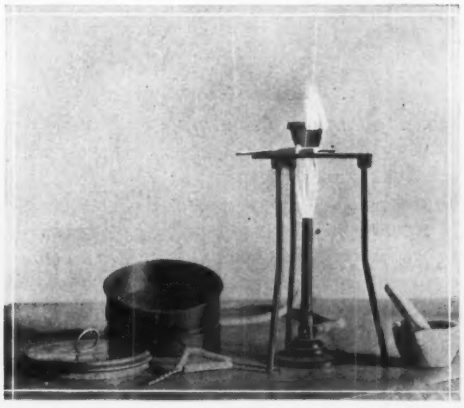

FIG. 5. DRIVING OFF VOLATILE COMBUSTIBLE. SIEVE, TRIANGLE, CRUCIBLE, TRIPOD, BUNSEN BURNER, MORTAR AND PESTLE USED IN COAL ANALYSIS

The proximate analysis of coal calls for a determination of the percentage of moisture, volatile combustible, fixed carbon and ash. Following is an outline of the process for obtaining these percentages:

An average sample is first obtained and weighed, the moisture is then dried out over a hot sand bath and the sample reweighed; the difference in the 2 weights gives the amount of moisture. The sample is then heated in the covered crucible over a bunsen burner for about 7 min. to drive off the volatile matter and the sample

reweighed, after which the crucible is placed with the cover removed over the bunsen flame or a blast flame until all carbon has been burned and nothing but ash remains which is then weighed; from these weights the amount and percentages of each constituent can be obtained.

Sampling Coal

TO secure an average sample is one of the essentials for a fair analysis of the coal. As coal comes from the mines in cars or from the dealer in wagons the fine particles collect at the bottom and that part of the load is apt to contain more ash than a sample taken from the top. The usual and recommended method of sampling coal in cars and wagons is to secure a shovelful from each end and the center, taking it from about the center of the pile up and down.

For the engine room, however, a fair sample can be secured by taking a small shovelful of coal from each barrow load, or perhaps each fifth load. Where coal is fed to the furnace by machinery, the samples may be taken from the hopper at regular intervals, the idea being always to secure an average sample of considerable size.

These samples taken from time to time should be kept in a covered barrel or box in the cooler part of the boiler room until such a time as it is desired to make the analysis. This precaution prevents the dust of the room from getting into the coal and prevents moisture of the coal from evaporating.

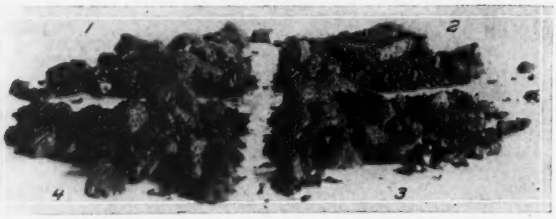

FIG. 1. QUARTERING COAL PREVIOUS TO MAKING AN ANALYSIS

Next comes the process of quartering which should be done as rapidly as possible. The sample as collected is roughly crushed and put in a low circular pile on a floor. After it has been thoroughly mixed, diameters are drawn at right angles through the coal and opposite quarters, those marked 1 and 3 in Fig. 1, are taken and treated in the same manner and the process of quartering, as it is called, is continued until the amount is reduced to the contents of a jar that can be sealed and handled readily.

Having collected the sample which is quite well ground, the next step is to pulverize a small amount, enough for about 4 or 5 tests, the usual amount used in each test is 1 gram. The pulverizing is done with the mortar and pestle and when it is thought to be fine enough the entire contents of the mortar is put through a sieve of from 50 to 75 meshes per inch. The precaution to observe here is that the entire sample worked with goes through the sieve; if it does not, grind the remainder until it does, as it is more than likely the particles that were too coarse to pass through the sieve the first time are sand which does not grind so readily as coal and to throw it away would make the result of the analysis too low in ash.

The Balance

FOLLOWING the preparation of the sample, the next step is the weighing of a crucible, but before we take this up let us get a clear idea of what a balance is like and how to use it and also the metric system of weights as this is the most convenient and commonly used for analysis of this kind.

As will be seen in the illustration, Fig. 2, the balance consists of a beam accurately balanced, from the ends of which are hung scale pans. To the center of the beam is attached a pointer which plays over a scale at the base of the supporting column. This column is hollow to provide for a rod which carries the main bearing at the top and is raised or lowered by an eccentric mechanism and the lever shown at the bottom. When not in use or when placing weights in the pans, the eccentric lowers the bearing and allows the beam to rest on the arms which extend from the top of the column, or beam arrest as it is called. All bearings are agate planes with agate knife edges which do not corrode, and maintain their frictionless quality indefinitely. At the ends of the beam are nuts on threaded studs which are used to balance the beam.

The entire instrument is supported on 3 adjustable screws and with the aid of a plumb bob the instrument may be leveled by adjusting the supporting screws.

While the above description applies specifically to the balance shown in the illustration, the principle of all balances is the same, the difference in construction being matters of detail to secure more or less accuracy. The balance shown is accurate to 1 milligram with a capacity of 60 grams which, for average power plant work, is sufficiently accurate for any tests the engineer may desire to make.

Weights

WHILE not absolutely necessary to use the metric system of weights with these balances, it is by far the most convenient both for rapidity in weighing and in calculating percentages.

In this system the gram is taken as the unit and is equivalent to 15.432 grains or 453.6 grams, equals 1 lb. avoirdupois; but for making an analysis this relation need not be kept in mind as the percentage of the different constituents is what is desired.

Weights for chemical balances are usually put up in a box with a cover, the small weights being kept from getting mixed up by an extra glass cover. The large weights, that is all above 1 gram, are of brass well polished to prevent corrosion and preserve their accuracy, cast with a knob on top to facilitate handling.

The fractional gram weights are made of platinum and aluminum, being flat with one edge or corner turned up to make them easily handled with the forceps which come with each set. The arrangement of weights in the box is as shown in the illustration, Fig. 3, and is the most convenient for handling when weighing. All weights of 1 gram or more are stamped with their value in grams while the smaller weights are stamped with their value in milligrams (abbreviated mg. and = 0.001 gram). Thus we have for a set of weights of 50 gr. to 1 mg., 2 20-gr. and 2-gr. pieces, 1 each of 10, 5, and 1 gr., and in the smaller weights, one 500-mg., two 200, and one 100-mg.; one 50-mg., two 20 and one 10-mg.; and one 5-mg., two 2 and one 1-mg. weights. This gives all the weights that are needed for convenience up to 65 gr. and would serve the purpose of any power plant engineer.

Using the Balance

WHEN using a balance, it must be kept constantly in mind that it is an instrument of precision and to preserve its value as such it must be handled with care and considerable delicacy. A place should be provided for it away from moisture and dirt to prevent corrosion of the metal parts and friction in the bearings.

When it is desired to use a balance of the type described above, place it on a solid table or shelf out of a draft, level it by means of the adjustable screws, then raise the beam by means of the eccentric lever. If the pointer swings to an equal distance each side of the center mark on the scale, the beam is properly balanced; if it does not, the heavy end will fall the lower and the pointer will swing farther toward the end of scale near the light scale pan. To correct this unbalancing, the nuts at the ends of the beam are screwed in or out as the case may be to make the arm lighter or heavier. When a balance is secured, the beam should be lowered to the supports by the lever.

When drying coal or making other determinations which require that the sample be cooled there is danger of the coal absorbing moisture before it can be weighed. To prevent inaccuracy due to moisture a desiccator is used this is a vessel which has a compartment at the bottom containing a chemical, usually calcium chloride or sulphuric acid, which has strong absorbing powers and so keeps the air in the vessel dry. The cover of the desiccator fits with a ground glass joint which is made air tight with a coating of vaseline.

The Actual Test

NOW that we have our coal prepared and balance adjusted, we will run through an actual test on bituminous coal. While in this case only one sample is taken, to avoid confusion, it is always best to run 2 tests side by side clear through the analysis as a check on one another and they should agree within 1/10 of 1 per cent if the analysis is made with any degree of accuracy.

For use in a power plant, porcelain crucibles will give sufficient accuracy, though for the most accurate determinations, a platinum crucible is used as it gives a more even heat to the sample; it is, however, very expensive and in this instance we will consider the use of porcelain crucibles only.

In preparing a crucible for weighing, it should be thoroughly cleaned and dried then placed over a bunsen burner and heated to burn off all foreign matter such as oil from the fingers. It is allowed to cool, as a high temperature is likely to affect the weight, then covered and placed upon the pan of the balance. From the time the crucible is cleaned until the analysis is finished, it should be handled entirely with tongs as the fingers may leave prints on it which would affect the weight.

For a right handed person it is most convenient to place the crucible in the left scale pan operating the eccentric lever with the left hand and leaving the right hand free to pick up weights. To preserve the accuracy of the weights, they should never be touched with the fingers as finger prints are likely to cause corrosion and destroy the value of the weights; forceps which accompany the set are used exclusively for this purpose.

Rapidity in weighing is gained only through practice, but a general rule to be followed is to start with weight heavier than the crucible or substance being weighed, in the present case we judge that the covered crucible does not weigh more than 10 grams so we place the 10 gr. weight in the right scale, raise the beam and find the weight too heavy; so we place the 10-gr. weight back in the box and put the 5 and two 2-gr. weights in the pan, and find this a little too heavy, so remove a 2-gr. weight and put in the 1-gr. weight and find this too light. We know now that the crucible and cover weigh between 8 and 9 grams so we leave the 8-gr. weights on the pan and add the 500-mg. piece and find it too light, we add 200 mg. more with the same result; another 200-mg. piece is too heavy, so we replace it with the 100-mg. piece and find it too light; so we have the first 2 figures of our weight. Now when we add the 50-mg. piece we find it too heavy, so we replace it with two 20-mg. pieces and find that our balance is correct, the pointer swinging the same distance on each side of the center mark of the scale, so we add up the weights we have placed on the balance as follows:

Grams		.....	5.
"		.....	2.
"		.....	1.
Milligrams	500 or	.....	.500 gr.
"	200 "	.....	.200
"	100 "	.....	.100
"	20 "	.....	.020
"	20 "	.....	.020
Total		.....	8.840 grams

As a check on this reading, it is well to count up what weights are missing from the box; this can easily be done as the compartments are made to accommodate individual weights.

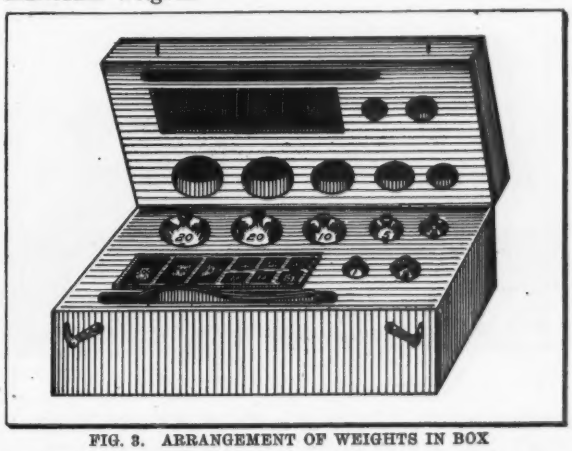

FIG. 3. ARRANGEMENT OF WEIGHTS IN BOX

In making a weighing, there are 2 other precautions that should be observed: The balance should be swinging when the final weight is taken, this is to insure that the bearings are not sticking; the balance need not come to rest, as this would probably take considerable time particularly, if the balance is in good condition, but by observing how far the pointer travels on each side of the center line of the scale it can easily be seen whether or not the center of travel is the center of the scale and when this occurs the balance is correct.

The other precaution is, when taking the final reading, to see that no draft is affecting the weight. To avoid drafts it is well to surround the balance with a box having an open front so that swing of the balance can be watched and weights changed if necessary.

Coal from the pan of the sieve is now put in the crucible. For best results with the apparatus which is described, about 1 gram is the most convenient weight, The crucible and its contents and the cover are again weighed and in our case the weight is found to be 9.845 grams, making the amount of coal $9.845 - 8.840 = 1.005$ gr.

The first determination to make is the amount of uncombined water. Having weighed our sample, the uncovered crucible is placed in a hot sand bed, the temperature of which is kept at close to 212 deg. F., for 1 hr. (no more) when it is again cooled with the cover on in a desiccator and weighed. Repeat the drying process for ½ hr. and reweigh. If the weight is constant or has increased, take the first weight, otherwise reheat for half hour periods and reweigh until weight does increase, using the lowest weight. The increase in weight is due to oxidation.

The loss in weight is due to loss of water. In our case we find the weight after drying to be 9.805 gr. The weight of moisture then is $9.845 - 9.805 = 0.04$ gr. and the percentage of moisture is $\frac{0.04 \times 100}{1.005} = 3.98$ per cent.

Volatile Combustible

AFTER the coal has been dried, the next determination in the proximate analysis, is the percentage of volatile combustible matter. This proportion of the coal is that which distils off at the lower temperatures in the furnace in the form of gas which is combustible and is composed almost entirely of hydrogen and carbon in varying proportions known as hydro-carbon. The quality of these gases will be given later.

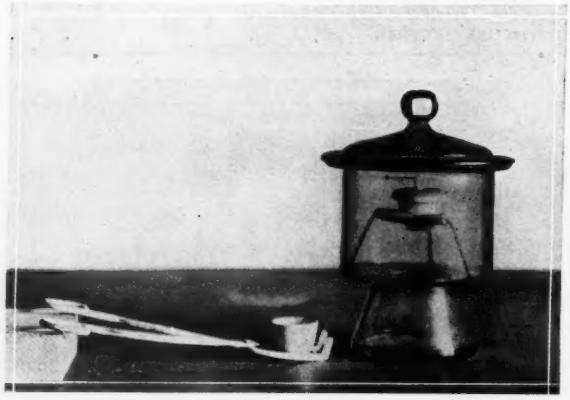

FIG. 4. DESICCATOR AND TONGS

Knowing the weight of the dry coal, the crucible is closely covered to prevent air from entering and is placed on a triangle over a bunsen burner. As soon as the crucible becomes hot, dark colored gases are driven out from under the cover and burn; when these gases have ceased to burn, continue heating the crucible for 5 minutes longer to make sure that the volatile matter has all been driven off, then cool in the desiccator and weigh.

Repeat the heating process with the cover on for 5 minutes, cool and weigh as before. If the loss in weight by the last heating is not more than 5 mg. take the first weight.

The loss in weight is caused by driving out the volatile matter in the coal and the residue is coke. To calculate the percentage of volatile combustible matter, divide the loss of weight due to this heating by the original weight of the sample and multiply by 100.

The crucible and sample with which we have been working when dried weighed 9.805 gr., the crucible and coke weighed 9.496 gr., therefore the weight of the volatile combustible is $9.805 - 9.496 = 0.309$ gr. and the percentage is $0.309 \div 1.005 \times 100 = 30.746$ per cent.

Fixed Carbon and Ash

COMING now to the last step in the proximate analysis, the uncovered crucible containing the coke is placed over the bunsen burner, or better still, if available, a blast flame or gasoline torch, until all the carbon has been burned out, this burning may take from 20 min. to an hour according to the means at hand, but when all burned the residue will appear light colored throughout and the crucible will have no black spots on it.

When the crucible has again been covered, cooled and weighed we can determine the amount of fixed carbon and ash in the following manner: Subtract the weight of the crucible as found in the beginning from the final weight and we obtain the weight of ash, in the case under consideration this amounted to 0.048 gr.; the percentage of ash calculated as above from the original sample is 4.776.

To get the amount of fixed carbon, subtract the final weight, which was 8.888 gr., from the weight of the crucible containing coke, 9.496, which gives 0.608 gr. The percentage, calculated as before, gives 60.498 per cent of fixed carbon.

Tabulating the above results to make them concise we have:

Moisture	3.98 per cent
Volatile Combustible	30.746 per cent
Fixed Carbon	60.498 per cent
Ash	4.776 per cent

The characteristics of these constituents, their chemical composition and effects upon the burning of the coal will be taken up in a future article.

TO FOSTER A BROADER commercial spirit between America and Germany, about 200 of the most prominent mechanical engineers of the United States will go to Europe this summer to attend the 54th Annual Meeting of the Verein deutscher Ingenieure in Leipzig and to inspect the educational and industrial establishments of Germany. The party will sail on June 10, on the Hamburg-American line S.S. Victoria Luise, the largest and most superbly appointed cruising steamer afloat. Many friends of the engineers are also planning to sail on the steamer and will probably compose the entire passenger list. The official party will consist of 200 members of The American Society of Mechanical Engineers, accompanied by 100 ladies.

The program will include many features of interest. On arriving in Hamburg on June 21, the great shipyards will be visited. The party will then proceed next day by special train to Leipzig. Here the King of Saxony will welcome the visitors and the Verein deutscher Ingenieure will tender an official reception at which the President of The American Society of Mechaincal Engineers, Dr. W. F. M. Goss, Dean of the College of Engineering of the University of Illinois, will make the principal address.

The party will leave on June 25 for a tour of industrial Germany, visiting Dresden, Berlin, Cologne, Dusseldorf, Frankfurt, Heidelberg and Munich, including a trip up the Rhine.

Independence Day will be celebrated at Frankfurt under the auspices of the American Embassy.

THE SPRING MEETING of The American Society of Mechanical Engineers will be held on May 20-23 in Baltimore, which with its remarkable harbor and nearness to Washington and Annapolis is a most attractive city in which to hold a convention.

THE DESIGN OF STEAM PIPING SYSTEMS

Formulae and Calculations Necessary for Determining the Amount of Friction and Pressure Drop in Horizontal and Vertical Steam Pipe Lines

By William F. Fischer

WHEN designing a system of steam piping, where the total length of any run, or branch pipe, is over 100 ft., friction should be taken into account, as it causes a drop in pressure in the piping system. Friction in steam pipes is caused by particles of steam rubbing against the inside surface of the pipe, which in turn, causes other particles of steam to rub, or roll around on themselves, as it were, while being carried along through the pipe.

Friction is greater near the surface of the pipe than toward the center; therefore, the steam flowing near the center of the pipe will flow at a much higher velocity than the steam near the surface. In other words, the velocity will be found to increase toward the center of the pipe and decrease toward the surface of the pipe.

Friction of steam in the pipe causes a loss in pressure, or a drop in pressure as it is called, and the boiler pressure must necessarily be increased to make good this loss in long pipes.

If we find, for example, that the steam in the pipe at a point near the boiler is under 150 lb. gage pressure, and at a point near the engine throttle, only 146.3 lb. gage pressure, we will have a drop in pressure of $150 - 146.3 = 3.7$ lb. per sq. in. at the engine throttle, due to friction and other losses.

If the pressure at the engine throttle was exactly the same as at the boiler nozzle, there would be no flow in the pipe as there can be no flow without a corresponding drop in pressure.

Therefore, in flowing from the boiler to the engine, the steam flows from a higher to a lower pressure and expands, or increases in volume, at the lower pressure. That steam expands in the pipe when flowing may be readily proven by reference to the steam tables, from which we find that 1 lb. of steam at 150-lb. gage pressure (approximately 165 lb. absolute) occupies 2.753 cu. ft. of space in the pipe, or in other words, the specific volume of saturated steam at this pressure is 2.753 cu. ft. per lb.

Then again, at 146.3 lb. gage pressure, $(146.3 + 14.7 = 161$ lb. absolute) 1 lb. of steam occupies 2.818 cu. ft. of space in the pipe, or the specific volume of steam at this pressure is 2.818 cu. ft. per lb.

From the above we see that a drop in pressure in the pipe causes steam to expand as the pressure is reduced. This in turn causes an increase in the velocity at which the steam is traveling in the pipe, as the weight of steam flowing each minute does not change, but remains the same in each case.

For example: In the above case, assume that the engine consumes 250 lb. of steam a minute, and that the pipe supplying the engine is a 5-in. standard weight steam pipe. We then have 250 lb. of steam flowing through the pipe, at any point, in 1 min. of time. At a point near the boiler the pressure is 150 lb. gage (165 lb. absolute) and at the engine throttle, the pressure is 146.3 lb. gage (161 lb. absolute).

From formulae given in previous issues on this subject, we have $V = \frac{144\,P\,S}{A}$ (Friction neglected)

in which V = Velocity of steam in feet per minute,
P = Weight of steam flowing, in pounds per minute,
S = Specific Volume, at the given pressure,
and A = Internal area of the pipe, in square inches.

Therefore, at a point near the boiler we have:
P = 250 lb., flowing per minute.
S = 2.753 cu. ft. per lb. at 150 lb. gage pressure.
A = 20 sq. in.—the internal area of a 5-in. pipe.

All of which when substituted in the above formula gives $V = \frac{144 \times 250 \times 2.753}{20} = 4950$ ft. per min., the approximate velocity at a point near the boiler.

At the engine throttle we have:
P = 250 lb. per min., as before.
A = 20 sq. in., as before,
and S = 2.818 cu. ft. per pound, at 146.3 lb. gage pressure.

Therefore $V = \frac{144 \times 250 \times 2.818}{20} = 5075$ ft. per min., the velocity at the engine throttle.

The difference in velocity at the 2 points is $5075 - 4950 = 125$ ft. per min.

The steam in expanding in the pipe, from a higher to a lower pressure, gives up heat. This heat, thus liberated, is not lost, however, as it tends to evaporate moisture and superheat the steam at the lower pressure.

From the steam tables we can readily determine the quantity of heat, or the number of heat units liberated by a pound of steam in expanding from one pressure to another (from a higher to a lower pressure).

For example: In the above case, we find from the "steam tables," that each pound of saturated steam at 150-lb. gage pressure contains 1195 B.t.u. (Total heat of the steam at this pressure) and each pound of steam at 146.3 lb. gage pressure contains 1194.6 B.t.u.

Therefore $1195 - 1194.6 = 0.4$ B.t.u. liberated per pound, while flowing from the boiler to the engine. As 250 lb. of steam is flowing per minute, we have $250 \times 0.4 = 100$ B.t.u. liberated per minute which goes to evaporate moisture, or to superheat the steam, if there is no moisture present. As a general rule, the superheating effect will be very slight, as shown in the above example, but will be found to increase with the pressure drop.

Flow of Steam in Pipes and Drop in Pressure Due to Friction

WE have seen that velocity and flow of steam in a pipe is produced by a difference in pressure between the steam in the boiler and the steam at the engine throttle. The velocity of steam flowing freely through a pipe is equal to the velocity of a body that has fallen through a distance equal to the difference in height of 2 columns of steam of 1 sq. in. cross-sectional area.

If we multiply the difference in pressure (pressure drop) between the boiler and engine, by the height of a column of steam, 1 in. square at the base and

weighing exactly 1 lb., we have the difference of pressure expressed in "feet of head."

Let h = feet of head, corresponding to a given drop in pressure in pounds per square inch;

g = acceleration due to gravity = 32.16;

and v = Velocity in feet per second.

Then from the formula for falling bodies we have:

$$v = \sqrt{2gh} \qquad \text{Formula 1.}$$

$$\text{or } h_1 = \frac{v^2}{2g} \qquad \text{Formula 2.}$$

where h_1 = the velocity head, in feet.

In the above, friction is neglected. The loss of head, in feet, due to friction may be expressed by the following formula:

$$h_2 = f \times \frac{4L}{d_1} \times \frac{v^2}{2g} \qquad \text{Formula 3.}$$

$$\text{from which } v = \sqrt{\frac{64.4}{4f} \times \frac{h_2 d_1}{L}} \qquad \text{Formula 4.}$$

where L = Strength of pipe, in feet.

d_1 = Diameter of pipe, in feet.

v = Velocity of steam, in feet per second.

f = Coefficient of friction.

g = acceleration due to gravity = 32.16.

and h_2 = Loss of head, in feet, due to friction.

Let V = Velocity of steam, in feet per minute = 60 v, and d = Inside diameter of pipe, in inches = $12 d_1$.

$$\text{Then } v = \frac{V}{60} \text{ and } v^2 = \left(\frac{V}{60}\right)^2 = \frac{V^2}{3600}$$

$$\text{also } d_1 = \frac{d}{12} \text{ and } \frac{1}{d_1} = \frac{12}{d}.$$

Therefore, subsituting the above in formula 3, we get:

$$h_2 = \frac{4fL}{2g} \times \frac{12}{d} \times \frac{V^2}{3600} = \frac{fLV^2}{150gd} \qquad \text{Formula 5.}$$

where h_2, f, L and g are same as above.

V = Velocity in feet per minute,

and d = Inside diameter of pipe, in inches.

If we divide the weight of a cubic foot of steam, in pounds, by 144, the number of square inches in one square foot, we obtain the weight of a column of steam 1 in. square at the base, and 1 ft. high, or in other words we obtain the pressure exerted in pounds per square inch per foot of head. Therefore, if we multiply this pressure in pounds per square inch per foot of head, by the total height, or head, in feet, we obtain the total pressure in pounds per square inch corresponding to the given head in feet.

Let p = Drop in pressure in pounds per square inch due to friction in the pipe;

and D = The Density of the steam, or the weight of a cubic foot of steam at the given pressure.

$$\text{Then } p = \frac{h_2 D}{144} \qquad \text{Formula 6.}$$

From Formula 5 we find that $h_2 = \frac{fLV^2}{150gd}$ and substituting these values in Formula 6 we have

$$p = \frac{fLV^2}{150gd} \times \frac{D}{144} = \frac{fLV^2D}{694{,}656\,d} \qquad \text{Formula 7.}$$

Now, let W = The weight of steam flowing in the pipe in pounds per minute.

$$\text{Then } W = \frac{V \times (d^2 \times 0.7854) \times D}{144} \qquad \text{Formula 8,}$$

$$\text{from which } V = \frac{144\,W}{0.7854\,d^2 D} \qquad \text{Formula 9,}$$

which when substituted in Formula 7, gives

$$p = \left(\frac{fLD}{694{,}656\,d}\right) \times \left(\frac{144\,W}{d^2 \times 0.7854 \times D}\right)^2 = \left(\frac{fLD}{694{,}656}\right) \times \left(\frac{20{,}736\,W^2}{0.6168\,d^4 D^2}\right)$$

$$p = \frac{20{,}736}{428{,}464} \times \frac{fLW^2}{d^5 D} \qquad \text{Formula 10.}$$

As established by Prof. Unwin, the coefficient of friction $f = K\left(1+\frac{3.6}{d}\right)$

where d = the inside diameter of the pipe in inches and K = A constant, determined by experiment, and generally accepted as 0.0027 for steam.

Therefore, $f = 0.0027\left(1+\frac{3.6}{d}\right)$ which, when substituted in Formula 10, gives

$$p = \frac{20{,}736}{428{,}464} \times 0.0027 \left(1+\frac{3.6}{d}\right) \times \frac{LW^2}{d^5 D}$$

$$p = 0.000{,}131 \times \left(1+\frac{3.6}{d}\right) \times \frac{LW^2}{d^5 D} \qquad \text{Formula 11,}$$

$$\text{from which } W = 87\sqrt{\frac{pDd^5}{L\left(1+\frac{3.6}{d}\right)}} \qquad \text{Formlua 12,}$$

the final form desired. This formula is known as "Babcock's formula for flow of steam pipes."

Where W = The weight of steam flowing in the pipe, in pounds per minute.

p = Drop in pressure, in pounds per square inch due to friction.

L = Length of pipe in feet.

d = Diameter of pipe in inches (inside diameter).

D = Density of the steam, or weight of a cubic foot of the steam, in pounds, at the given pressure.

Using the formulae in the form as given in 11 and 12 is rather tedious work, especially if there are many computations to be made. For this reason the writer has decided to simplify the formula somewhat, by calculating the values of $\frac{0.000{,}131\left(1+\frac{3.6}{d}\right)}{d^5}$ from Formula 11.

These values will be found under Constant K in the table for pipe from 1-in. to 24-in. inclusive. Also from Formula 12—values of $87\sqrt{\frac{d^5}{\left(1+\frac{3.6}{d}\right)}}$ have been calculated and are as given under Constant C, of the table.

Therefore, simplifying Formula 11 we have

$$p = K \times \frac{LW^2}{D} \qquad \text{Formula 13,}$$

$$\text{or } p = K \times LW^2 S \qquad \text{Formula 14,}$$

and simplifying Formula 12 we have

$$W = C\sqrt{\frac{pD}{L}} \qquad \text{Formula 15.}$$

Where K and C are constants, varying with the diameter of the pipe, as given in the table.

L = Length of pipe in feet.

W = The weight of steam flowing in the pipe, in pounds per minute.

D = Density of the steam, or the weight of a cubic foot in pounds, at the given pressure.
S = Specific volume of the steam, or number of cubic feet per pound, at the given pressure.
and p = Drop in pressure, in pounds per square inch, due to friction.

Practical Examples

AS an example showing the use of the formula, take the following: 250 lb. of saturated steam are to be conveyed per minute, through a 5-in. standard-weight pipe. The pipe, from boiler to engine is 300 ft. in length. The steam pressure carried on the boiler

CONSTANTS USED IN CALCULATION OF STEAM FLOW

Nominal Pipe Size—Inches	Actual Inside Diameter Inches=d	Values of Constant "C"	Values of Constant K	Equivalent Length of Pipe, in Feet, to be Added for each Globe Valve and Entrance	Equivalent Length of Pipe, in Feet, to be Added for each 90° Elbow.
1	1.047	46	0.000,466	2	1.5
1¼	1.38	102	0.000,095	4	3.0
1½	1.61	159	0.000,039	5	3.5
2	2.067	320	0.000,009,5	7	5
2½	2.467	543	0.000,003,6	10	6
3	3.066	977	0.000,001,1	14	9
3½	3.548	1410	0.000,000,47	17	11
4	4.026	2016	0.000,000,24	20	13
4½	4.508	2795	0.000,000,13	24	16
5	5.045	3724	0.000,000,07	28	19
6	6.065	6210	0.000,000,026	37	24
7	7.023	9198	0.000,000,011	44	29
8	7.981	13,050	0.000,000,005,8	53	35
9	8.937	17,787	0.000,000,003,1	61	41
10	10.018	23,605	0.000,000,001,8	70	47
11	11	30,276	0.000,000,001,1	78	52
12	12	38,074	0.000,000,000,7	88	58
	14	56,862	0.000,000,000,31	106	70
	16	80,384	0.000,000,000,15	123	82
	18	109,281	0.000,000,000,083	143	95
	20	143,120	0.000,000,000,048	162	107
	22	183,870	0.000,000,000,03	181	120
	24	229,993	0.000,000,000,02	200	132

is 150 lb. per sq. in. gage (165 lb. absolute). What loss of pressure in pounds per square inch may we expect at the engine throttle?

By Formula 11 we have

$$p = 0.000,131 \left(1+\frac{3.6}{d}\right)\frac{L\,W^2}{d^5\,D}$$

L = 300 ft.
W = 250 lb. per min.
$W^2 = 250 \times 250 = 62,500$.
D = 0.3633 (from steam tables).
d = 5.045 in. inside diameter of 5-in. pipe.
$d^5 = (5.045)^5 = 3200$ approximately.

Substituting these values in Formula 11 we have,

$$p = 0.000,131\left(1+\frac{3.6}{5.045}\right)\times\frac{300\times 62,500}{3200\times 0.3633} = 0.000,131\times$$

$1.714 \times 16,128 = 3.62$ lb. per sq. in., the pressure drop at the engine throttle. Therefore, the pressure at the throttle will be $150 - 3.62 = 146.38$ lb. per sq. in. gage, approximately.

Using Formula 13 for the same example, we get:

$$p = K \times \frac{LW^2}{D}$$

L = 300 ft.
$W^2 = 250 \times 250 = 62,500$.
D = 0.3633 as before,

and K from the table for 5-in. pipe = 0.000,000,07, which when substituted in Formula 13, gives

$$p = 0.000,000,07 \times \frac{300\times 62,500}{0.3633} = 0.000,000,07 \times 51,-$$

610,000 = 3.62 lb. per sq. in. drop in pressure at the engine throttle.

As an example showing the use of Formulae 12 and 15, take the following:

How many pounds of saturated steam will be conveyed through a 5-in. standard weight pipe in 1 min., if the pipe is 300 ft. long, the boiler pressure 150 lb. gage, and the drop in pressure at the engine throttle is 3.62 lb. per sq. in.?

By Formula 12 we get $W = 87\sqrt{\frac{p\,D\,d^5}{L(1+\frac{3.6}{d})}}$

p = 3.62.
D = 0.3633.
d = 5.045.
$d^5 = 3200$.
L = 300 ft.

Therefore $W = 87\sqrt{\frac{3.62\times 0.3633\times 3200}{300\times(1+\frac{3.6}{5.045})}} = 87\sqrt{8.22}$

$= 87 \times 2.87 = 250$ lb. per min., approximately.

By Formula 15 for the same example, we get:

$$W = C\sqrt{\frac{p\,D}{L}}$$

p = 3.62.
D = 0.3633.
L = 300.

and C, from the table (for 5-in. pipe) = 3724.

Therefore $W = 3724\sqrt{\frac{3.62\times 0.3633}{300}} = 3724\times$

$\sqrt{0.004,383,8} = 3724 \times 0.0663 = 247$ lb. per min., approximately.

A study of the above examples will show a considerable saving in time, by the use of the constants given in the table.

Equivalent Length of Pipe for Each Globe Valve, Entrance, or Elbow

IN addition to the loss of pressure due to friction, there is also a loss of pressure due to a change in the velocity of the steam at the entrance to the pipe. This drop in pressure due to getting up velocity in the pipe is very slight and is seldom taken into account.

Elbows, globe valves, and a square-ended entrance to the pipe, such as occurs when steam is taken off through a tee at right angles to the main, all offer resistance to the flow of steam, thus causing a drop in pressure, which should be taken into account and proper allowance made for it.

Friction is always greater through short radius elbows and tees, than through elbows and tees of long radius. The resistance offered by a globe valve is about ⅓ greater than that due to a short radius elbow, whereas gate valves offer practically no resistance to the flow providing they are opened wide. The resistance offered by a square-ended opening, or at the outlet of a tee where a branch is taken off at right angles, is about the same as that for a globe valve having the same size opening. The resistance offered by a long radius pipe bend is very slight and may be taken as equal to the resistance offered by the same length of straight pipe, or in other words, all pipe bends may be considered as straight pipe of equal length.

It is customary to consider the resistance offered by valves and fittings, etc., as equivalent to a length of straight pipe which will offer the same resistance, or cause the same drop in pressure. When this equivalent length has been determined it should be added to length L in the formula, and p, or w, computed accordingly.

Briggs, in his "Warming Buildings by Steam," gives:

Equivalent length of straight pipe, in inches, to be added for each globe valve, or square-ended opening $= \frac{114\,d}{(1+\frac{3.6}{d})}$ Formula 16.

Equivalent length of straight pipe, in inches, to be added for each 90-deg. elbow in the line $= \frac{76\,d}{(1+\frac{3.61}{d})}$ Formula 17.

Where d = inside diameter of pipe in inches. The values in the table have been computed from the above formulae (16 and 17).

For example showing use of the table, equivalent lengths, take the following:

In a 5-in. steam main, 300 ft. long, there is 1 globe valve, 4 90-deg. elbows, and steam enters the branch through a 5-in. short radius tee giving a square-ended entrance; what length of straight pipe should be added for the above, and what total length L, should be used to calculate pressure drop, p, or weight of steam delivered, W, from formulae as given?

Answer—Looking in the table we find the equivalent length of straight pipe to be added for a 5-in. globe valve, is 28 ft., and for a square-ended entrance, 28 ft. also.

For a 5-in., 90-deg. elbow, we find the equivalent length to be 19 ft., and as there are 4 elbows in the line, we add $4 \times 19 = 76$ ft. for the elbows. Therefore, the total length (L) to be used in the formulae, will be $300 + 28 + 28 + 76 = 432$ ft.

Cases will quite frequently arise in practice, where, in a short run of pipe (say 70 or 80 ft. long), numerous elbows will be required to carry the line around obstructions. In this case the equivalent length to be added, in order to take care of valves and fittings, will greatly exceed the actual length of straight pipe. For this reason valves and fittings should never be neglected, especially in short mains and branches, when calculating pressure drop.

When calculating the size of a steam pipe to convey a given weight of steam in pounds per minute, at a given velocity, in feet per minute, it will be convenient to use the table given in the Reference Tables of the Dec. 15, 1912 issue for approximate pipe sizes. The pressure drop may then be computed by the aid of formulae as given above, and if the loss in pressure due to friction is found to be excessive, a larger pipe may be used. The pressure drop at the engine throttle should never be such as to interfere with the successful operation of the engine units when handling maximum or peak loads.

No rule can be given for allowable pressure drop most suitable for any given set of conditions, as this will have to be determined for each individual case. In the general run of power plant work, where pipe lines are not of very great length, from 1 to 2 lb. drop may be allowed for each 100 ft. of pipe, or its equivalent in elbows, valves, and other fittings.

Some designers allow for a pressure drop of from 1 to 3 lb. at the engine throttle and estimate the pipe sizes accordingly.

A pressure drop of 5 lb. or more should not be considered excessive, providing the boiler pressure is increased sufficiently to make good the loss and thus deliver the steam to the engines, at the required pressure for economical operation.

Vertical Pipes

WHEN steam is flowing upward through long vertical pipes the force of gravity should be considered. This will be better understood when we take into account the number of pounds of steam to be elevated from a lower to a higher level, in a given time. What we are chiefly interested in, however, is the loss of pressure caused by the vertical column of steam in the pipe.

This may be determined approximately as follows:

Let p_1 = Drop in pressure in pounds per square inch at the top of the pipe, due to vertical column of steam.

L_1 = Vertical length of pipe in feet.

and D = Density of steam, or the weight of a cubic foot at the given pressure.

Then $p_1 = \frac{L_1 D}{144}$

For example: Assume a vertical pipe 300 ft. in length, and steam pressure of 150 lb. per sq. in. gage.

Then $p_1 = \frac{300 \times 0.3633}{144} = 0.76$ lb. per sq. in., the pressure drop due to the vertical column of steam. To this should be added the pressure drop in 300 ft. of pipe due to friction, and the sum of the two will equal the total drop in pressure.

If the steam was flowing downward in the pipe, i.e., from a higher to a lower level of 300 ft., the pressure would be increased approximately 0.76 lb. per sq. in.

ADJUSTING THE WATER SUPPLY

By G. H. Brough

SOME years back in the past, on taking charge of a brick and tile works plant, I found 2 boilers 60 in. by 16 ft., supplying an Elliston slide valve engine of ancient vintage. This engine had the steam chest on top, long ports and the rocker arm motion, with the valves set to cut off at practically full stroke. The boss of the mill picked up a second-hand sensitive governor, almost new, which went on to the engine easily and with its pulley lined up with the shaft wheel, started off bravely, but for a long time the stem would jump with each rush of steam to the cylinder.

To avoid this, I put 2 pulleys on the same shaft and hung them above the engine as a countershaft, using 2 belts from the shaft to the governor. This gave a certain come and go between the governor and the shaft, so that the desired speed was reached and the governor quit jumping. The first chance I got I took off the steam chest cover and set the valve over to cut off at ⅝ stroke, the result being a change in the fuel consumption which greatly astonished all around the mill.

Water supply came into the back end of the engine room, a duplex pump pulling water from the pond into an old boiler outside, set high enough to fill the boilers on wash-out days. Feed to the boiler was through a 1¼-in. injector, which was at the back of the boilers. Shortly I brought this injector to the front where it was handy to keep track of, and after a time got the boss to supply a little Dean duplex steam pump which would handle hot water. We then piped the exhaust into the old boiler outside, using it as a feed-water heater, or as a storage tank for cold water when we used the injector.

POWER PLANT RECORDS

By C. E. Anderson

A GREAT deal has been written in the technical press regarding power plant records and the way to keep them so that the cost of operation is known at all times.

No doubt a great many engineers are starting to keep records of operation or wish to improve on those they have been using.

We will designate Boiler Room Report as sheet No. 1. Column 1 is for the time. We have 2 steam headers, one for power house and one for the packing house and other uses about the plant. In this way we know how much steam is used by power and by the rest of the plant. Columns 2 and 3 give the pressure on these headers. Column 4 is the temperature

SULZBERGER & SONS COMPANY

CHICAGO, ILL.

BOILER ROOM REPORT.

FROM 7 A. M. 1-10-13 TO 7 A. M. 1-11-13

Time	Steam Pressure House	Steam Press. on Power	Temp Boiler Room	Temp Cold Water to Heater	Temp Pump Section	Temp Boiler Feed	Temp Flue Gases	Draft Gage	BACK PRESS. ON HEATER	REMARKS
7 a. m.	80	150	80°	75°	75°	220°	600°	.33"	2.5 LB.	#2 Boiler down for cleaning
8 a. m.	"	"	"	"	"	"	"	"	3	"
9 a. m.	"	"	"	"	"	"	"	"	4	"
10 a. m.	"	"	82°	"	"	"	675°	"	5	"
11 a. m.	"	"	"	80°	80°	215°	"	"	"	"
12 noon	"	"	"	"	"	"	"	"	"	"
1 p. m.	75	145	"	"	"	"	"	"	"	"
2 p. m.	"	"	"	"	"	210°	"	"	"	"
3 p. m.	"	"	"	"	"	"	"	.32"	"	"
4 p. m.	"	"	80°	"	"	"	"	"	"	"
5 p. m.	70	150	"	75°	75°	"	670°	"	"	"
6 p. m.	"	"	"	"	"	215°	"	"	"	"
7 p. m.	"	"	"	"	"	"	"	"	4	"
8 p. m.	"	"	"	"	"	"	650°	"	"	"
9 p. m.	75	"	"	"	"	"	"	"	"	"
10 p. m.	"	"	78°	"	"	220°	"	.33"	"	"
11 p. m.	"	"	"	72°	72°	"	"	"	3.5	"
12 night	80	"	"	"	"	"	"	"	"	"
1 a. m.	"	"	"	"	"	"	"	"	"	"
2 a. m.	"	"	"	"	"	"	"	"	"	"
3 a. m.	"	"	"	"	"	"	"	"	"	"
4 a. m.	"	"	"	"	"	"	"	"	"	"
5 a. m.	"	"	"	"	"	200°	660°	"	"	"
6 a. m.	"	"	"	"	"	"	"	"	"	"
Average	76	148								

Boilers Under Steam, First Watch—On Power Header 8 On House Header 8

Boilers Under Steam, Second Watch—On Power Header 8 On House Header 8

Boilers Cleaned 1 Approx. Boiler H. P. 3200 Approx. Water Pumped 65000 GAL.

Materials Used.

Boiler Compound 12 lbs. Engine Oil 1 PT. pts.

Waste 1/8 lbs. Cylinder Oil 1QT. pts.

Core Coal Unloaded—First Watch 2 Net Tons 100

Core Coal Unloaded—Second Watch 2 Net Tons 100

Meter Reading 596,885

Fireman First Watch

Fireman Second Watch

Approved Head Fireman

Approved Chief Engineer

FIG. 1. DAILY RECORD OF BOILER ROOM

MOTOR RECORD

Motor No. _____ H.P. _____ Location _____

Date From _____ To _____ One Week

Day		Time Started	Time Stopped	Visits 1	2	3	4	5	6	7	8	9	10	11	12	Hours Run	Remarks Trouble, Condition, Load, Etc.
Monday	6 A.M. — 6 P.M.																
	6 P.M. — 6 A.M.																
Tuesday	6 A.M. — 6 P.M.																
	6 P.M. — 6 A.M.																
Wednesday	6 A.M. — 6 P.M.																
	6 P.M. — 6 A.M.																
Thursday	6 A.M. — 6 P.M.																
	6 P.M. — 6 A.M.																
Friday	6 A.M. — 6 P.M.																
	6 P.M. — 6 A.M.																
Saturday	6 A.M. — 6 P.M.																
	6 P.M. — 6 A.M.																
Sunday	6 A.M. — 6 P.M.																
	6 P.M. — 6 A.M.																

Total Hours Run for Week _____

NOTE: IF MOTOR IS RUNNING, CHECK VISIT THUS: O AND TIME
IF MOTOR IS NOT RUNNING, CHECK VISIT THUS: X AND TIME

Signed _____ Motor Tender

FIG. 5. MOTOR REPORT SHEET

We use the accompanying set of sheets in our plant which are self explanatory. These records are for 24 hr. operation of the plant. For a smaller plant than this the record items can be condensed somewhat to suit the needs of the plant.

of the fire room. Column 5 is for temperature of the cold water to heater, so is column 6. The feed-water temperature entering the boiler is designated in column 7, columns 8 and 9 are for the temperature of flue gas and draft gage reading. The next column is

for the back pressure on the feed-water heater. The rest of the space on this sheet is self explanatory. The next sheet is Engine Report and we will designate this sheet as No. 2.

Columns 1 and 2 are as on sheet No. 1, next column is the receiver pressure between high and low-pressure cylinders. Column 4 is for the vacuum, column 5 is for the temperature of the condensing water before it

SCHWARZSCHILD & SULZBERGER CO.

CHICAGO, ILL.

ENGINE REPORT.

ENGINE NO. 3 FROM 7 A. M. 1-10-13 TO 7 A. M. 1-11-13

Time	Steam Press	Int. Receiver	Vacuum	Temp. Condens'g Water	Temp. Condens'r Discharge	Temp. Condens'r Steam	Speed	Amps	Volts	Watts	Turbine	REMARKS
7 a. m.	150	3	26	60	90	90	125	3600	230	828000		
8 a. m.	"	"	"	"	"	"	"	4000	"	920000		
9 a. m.	"	"	"	"	"	"	"	"	"	"		
10 a. m.	"	"	"	"	"	"	"	"	"	"		
11 a. m.	"	"	"	65	95	95	"	"	"	"		
12 noon	"	"	"	"	"	"	"	3500	"	805000		
1 p. m.	145	4	25	"	"	"	"	4000	"	920000		
2 p. m.	"	"	"	"	"	"	"	"	"	"		
3 p. m.	"	"	"	"	"	"	"	"	"	"		
4 p. m.	"	"	"	"	"	"	"	"	"	"		
5 p. m.	150	"	"	"	"	"	"	4100	"	943000		
6 p. m.	"	"	"	60	90	90	"	"	"	"		
7 p. m.	"	3	26	"	"	"	"	3600	"	828000		
8 p. m.	"	"	"	"	"	"	"	"	"	"		
9 p. m.	"	"	"	"	"	"	"	"	"	"		
10 p. m.	"	"	"	"	"	"	"	3500	"	805000		
11 p. m.	"	2	"	55	85	85	"	3300	"	759000		
12 night	"	"	"	"	"	"	"	3000	"	690000		
1 a. m.	"	"	"	"	"	"	"	"	"	"		
2 a. m.	"	"	"	50	80	80	"	"	"	"		
3 a. m.	"	"	"	"	"	"	"	"	"	"		
4 a. m.	"	"	"	"	"	"	"	"	"	"		
5 a. m.	"	"	"	"	"	"	"	"	"	"		
6 a. m.	"	"	"	"	"	"	"	"	"	"		

Engineer First Watch

Engineer Second Watch

Approved

Chief Engineer

FIG. 2. DAILY RECORD OF ENGINE

SCHWARZSCHILD & SULZBERGER CO.

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ICE MACHINE REPORT.

ENGINE NO. BALL COMPRESSORS FROM 7 A. M. 1-10-13 TO 7 A. M. 1-11-13

Time	Steam Press	Int. Receiver	Vacuum	Temp. Condens'g Water	Temp. Condens'r Discharge	Temp. Condens'r Steam	Speed	Ammonia: Back Press.	Ammonia: Compress. Press.	Condens'r Water: Before	Condens'r Water: After	Brine Temp.: Discharge	Brine Temp.: Return	Tanks: Inside	Tanks: Outside	Tank: Back Press.	Tank: Cond. Press.	REMARKS
7 a. m.	150	8	26	60	90	90	50	18	150	43	52	18	25	92	32	18	150	
8 a. m.	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
9 a. m.	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
10 a. m.	"	"	"	"	"	"	"	"	"	"	"	"	"	"	34	"	"	
11 a. m.	"	"	"	65	95	95	"	"	"	"	"	"	"	"	"	"	"	
12 noon	"	"	"	"	"	"	"	"	"	"	"	"	"	93	"	"	"	
1 p. m.	145	7	25	"	"	"	"	"	"	44	53	"	"	"	36	"	"	
2 p. m.	"	"	"	"	"	"	"	"	"	"	"	17	24	"	"	"	"	
3 p. m.	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
4 p. m.	"	"	"	"	"	"	"	"	"	"	"	"	"	"	33	"	"	
5 p. m.	150	8	"	"	"	"	"	"	"	"	"	"	"	96	"	"	"	
6 p. m.	"	"	"	60	90	90	"	"	"	42	51	16	23	"	"	"	"	
7 p. m.	"	"	26	"	"	"	"	"	"	"	"	"	"	"	32	"	"	
8 p. m.	"	"	"	"	"	"	"	"	"	"	"	"	"	94	"	"	"	
9 p. m.	"	"	"	"	"	"	"	"	"	"	50	"	"	"	"	"	"	
10 p. m.	"	"	"	"	"	"	"	"	"	"	"	"	"	93	31	"	"	
11 p. m.	"	"	"	55	85	85	45	16	145	"	"	15	22	"	"	16	145	
12 night	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
1 a. m.	"	"	"	"	"	"	"	"	"	"	"	"	"	90	30	"	"	
2 a. m.	"	"	"	50	80	80	"	"	"	"	"	"	"	"	"	"	"	
3 a. m.	"	"	"	"	"	"	"	"	"	"	49	"	"	88	"	"	"	
4 a. m.	"	"	"	"	"	"	"	"	"	"	"	"	"	"	29	"	"	
5 a. m.	"	"	"	"	"	"	"	"	"	"	"	14	21	"	"	"	"	
6 a. m.	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	

Engineer First Watch

Engineer Second Watch

Brine Density 62 Room Temp. 16°

Approved

Chief Engineer

FIG. 3. REPORT OF ICE MACHINE

Each engine has a report sheet made out similar to this one but we will only consider one sheet from engine known as No. 3, which is a large 1500-hp. Porter Allen engine driving a 1000-kw. generator.

enters the condenser which is a barometric type of condenser. Columns 6 and 7 are the temperatures of mixed water and condensed steam leaving the condenser. The other items are self explanatory.

Each department in the plant has a wattmeter, so that the amount of power used by each department for any given time can be ascertained by the daily wattmeter readings of the different department meters.

The next sheet, designated as No. 3, is the Ice Machine Report. Columns 1, 2, 3, 4, 5, 6 and 7 are the same as on sheet No. 2. The 8th column is the speed of the ammonia compressor, the next 2 columns are for the suction and discharge pressures respectively of the ammonia compressor.

The next 2 columns, numbers 11 and 12, are the temperature of the water before and after leaving the ammonia condenser which is of the double tube type. The next 2 columns are for the temperature of the brine, then 2 columns are provided for recording the inside temperature of the engine room and the temperature outside. The last 2 columns are the suction and discharge pressures of a York 250-ton ice machine which is working under the same conditions, practically, as the Ball ice machines, so no separate sheet is kept of this machine.

Schwarzschild & Sulzberger Company

CHICAGO, ILL.

DAY Power Report, 6 A.M. to 6 P.M., Date 1-10 1913

POWER HOUSE

No. Boilers in use	9	12	No. 1 Power Engine Run	10	30
" Firemen -	4	12	" 2 " " "	11	—
" " Helpers	2	12	" 3 " " "	12	—
" Ash Handlers	2	12	Turbine Power Engine Run	6	1
" Coal Heavers	4	12	No. 1 Ice Machine Run	12	
" Engineers -	3	12	" 2 " " "	12	
" Oilers -	4	12	" 3 " " "	12	
" 1 Circulating Pump Run	12	—	" 4 " " "	—	
" 2 " "	12	—	" 5 " " "	—	
" 3 " "	—	—	Fire Pump Run -	12	
" 4 " "	8	30	Turbine Pump Run	6	

BRINE TANK HOUSE

No. 1 Brine Pump Run	12 Hrs	No. 4 Power Engine Run	12 Hrs
" 2 " " "	12 "	Air Compressor Run	10 "
Steam Pump Run -	12 "	Arctic Compressor Run	12 "
		Motor Run - -	10 "

No. Oilers -	1	12
No. Brine Tenders	2	12

Average temperature of brine discharge 10°

Average temperature of brine return 23°

Remarks

Signature

ENGINEER IN CHARGE

ASSISTANT CHIEF ENGINEER

FIG. 4. MISCELLANEOUS DAILY REPORT

Sheet No. 4 is a sort of resume or daily report of the other reports combined, which is filed in the power house for reference.

Sheet No. 5 is a motor record sheet.

We have about 150 motors throughout the plant, ranging from 5 to 150 hp. Motor tenders travel regular beats and inspect the motors and oil them.

In a tin case on the wall near the motor these cards are placed and the motor tender marks the time of his visit, also any defects that he finds. If defect is of a serious nature he shuts down the motor or calls on the trouble man, as the case may be, to repair it.

These record cards are good for one week. In the power house we have a ledger showing the total power delivered by each motor to date or since its installation and the initial cost of the motor, also a record and cost of the repairs up to date since its installation.

By keeping a careful record performance of the different makes of motors we have, such as cost of repairs and their efficiency, we are able to judge which type and make of motor is most suitable for our line of work.

A STUDY ON THE COST OF POWER

FOR the purpose of determining whether purchased power or power generated at the plant would be cheaper, Lockwood, Greene & Co., Boston, made a survey of the situation with respect to a large cotton mill in Massachusetts, consisting of a 5-story spinning mill and a 2-story weave shed for making fine goods. The first installation contemplates 110,000 spindles and 2600 looms, with provision for an ultimate extension to 170,000 spindles and 4000 looms. Both the steam generating plant and the transformer substation for purchased power are assumed large enough to house the full equipment necessary for the ultimate size of plant.

The cost of power at the switchboard is taken in both cases. This board contains distributing switches for the mill circuits; and is located in the engine room of the steam power station, or in a small transformer building under constant charge of an attendant, if power is purchased. The amount and value of land required for the steam power house has not been estimated, as it was assumed that space could be found upon the mill property. The cost of power for driving machinery alone is first considered, no account being taken of lighting, fire protection, heating or steam for manufacturing purposes. The last two items are considered separately.

The total horsepower required to drive all the machinery in the mill was determined, with allowances made to cover losses in shafting, motors, etc., up to the switchboard. The total power at this point was found to be 4191 hp. or 3143 kw., assuming every machine running. With the nominal conditions of operation, each machine would be idle about 10 per cent of the time, so that the average load on the power plant would be 3772 hp. or 2829 kw.

The first cost for steam generating plant, considering a building of which the engine room, boiler room, pump house, chimney, and coal pocket accounts for $85,000. The 35-ton electric traveling crane, together with an equipment of automatic sprinklers and miscellaneous items, brings the general equipment up to $5000. The steam plant equipment, including 7 boilers, 2 engines, auxiliary engine, 2 condensers, 2 primary heaters, 2 feed pumps, secondary heater, and the smoke flue, piping, covering, oiling system, and foundations is estimated at $152,000. The electrical equipment, including 2 2000-kw. generators, 2 small generators, small motor generator set and switchboard, station wiring, and cost of erection is figured at $51,200. Engineering and contingencies, 10 per cent of the preceding totals, is $29,300, which makes the total first cost stated.

The total first cost for purchased power, estimating on a building of 6000 kw. and equipment of 4000 kw., is $27,500. This includes building $4000; 2 2000-kw. transformers (13,000 to 600 volts), high-tension equipment and wiring, switchboard and erection expenses, $21,000. Engineering and contingencies is 10 per cent, or $2500, making the total first cost as stated.

The operating cost in both cases includes capital charges; interest is figured at 6 per cent upon the total first cost; taxes and insurance at one per cent upon the net first cost, exclusive of engineering charges; depreciation at 2 per cent upon buildings and 4 per cent upon equipment; and maintenance at one per cent upon net first cost. The time of operation is the same in both cases, including 9 hr. a day or 54 hr. a week for 307 days in the year, thus allowing for 52 Sundays and 6 holidays. This makes 2763 hr. a year, which at 2829 kw. accounts for 7,816,427 kw.-hr. in the year.

Under the heading of steam plant, the capital charges per annum amount to $35,242. The direct operating costs amount to $43,978; or a total of $79,220. Operation is figured upon 17.9 lb. of water a kw.-hr. (with a 10 per cent waste in the feed pump), and 9 lb. of water evaporated per pound of coal. This makes a total of 8537 tons of coal a year, which with 20 per cent added for nights, Sundays, and holidays, makes 10,244 tons. Using a mixture of 80 per cent hard coal at $3 a ton, and 20 per cent soft coal at $4.10, the unit cost of coal is $3.22. This makes the coal $32,985. Engine room labor, including chief engineer, assistant engineer, and one oiler, is $3400. Boiler room labor, including 3 firemen, 2 coal passers, night fireman, and man Sundays and holidays, is $3493, while waste and supplies, $4100, complete the list.

Under purchased power capital charges are $3070; substation attendant, $1000, and power, at 1.34 cents a kw.-hr. (which was quoted by a power company in the neighborhood) amounts to $104,734, giving a total of $108,804.

Using the normal load factor of 90 per cent, the figures already given show that the cost a kilowatt-hour at the switchboard with the steam plant amounts to 1.014 cents, equivalent to $21 a hp.-yr. The corresponding cost a kw.-hr. with purchased power amounts to 1.39 cents or $28.85 a hp.-yr.

Taking account now of the fact that with the steam power plant steam would be available for slashing and for steam heating, while for purchased power this would have to be supplied separately, the difference in favor of the steam power plant becomes even more marked. The first cost has already been provided for in arranging for the steam power plant itself, while with the purchased power the cost of buildings and boilers would amount to $10,800. With the steam power plant, coal amounting to $10,450 and labor $350, makes a total of $10,800. With purchased power, coal for heating amounting to $11,750, together with labor and supplies $1383, and capital charges $1876, makes a total of $15,009, or an excess of $4209.

We thus have the final annual costs as follows:

Steam power	$79,220	
Steam for heat and manufacturing	10,800	
Total		$90,020
Purchased power	108,804	
Steam for heat and manufacturing	15,009	
Total		123,813

In order to bring the 2 costs to the same figure, it would be necessary to obtain electric power at 0.985 cent a kw.-hr.

A MOTOR VEHICLE and water purifying plant combined has been devised for army service. The body of the wagon consists of tanks and pipes The engine which drives it is also used to pump water from a stream, well or other source, and force it through clay filters The wagon can supply 500 gal. of clarified water an hour.—Engineering and Contracting.

INSTRUCTIONS FOR FIREMEN

A Chief Engineer's General Instructions to His Firemen

By Asa P. Hyde

COVERING.—There is a right time for it to be done; find it and do it then, so far as possible, while the damper is closed. Covering one side at a time only, and that lightly, not so heavily that fire cannot be seen through. Doing this as quickly and evenly with as few scoopfuls as possible (not overloaded scoops). This is a knack so to handle the scoop that the coal will be evenly and easily scattered and cover the entire fire. It requires practice, but must be acquired.

From 4 to 6 scoops is enough to cover a side. Do not putter by throwing several half-loaded scoops in, thus holding the doors open an unnecessary length of time. The quicker and neater the firing is done the more satisfactory the work and results. The inrush of cold air through an open door at firing or cleaning times is ruinous to the entire apparatus, and by proper managing can be largely avoided, and it must be done.

Except in extremes, always have ash pit doors open; this preserves the grates and pits. Carry some water in the pits, but not enough to make a nuisance in the ashes.

Keep fires back to inner edge of dead plate—no fire or coal on it. This must be attended to as it saves plates, brick, fronts, etc., and coal laying there is simply wasted. Keep floors clean at all times, no coal to stand or track in, either in front of arches or in bin. This will greatly lessen the work of cleaning up in the plant.

Burning Fires Low or Out

DO not allow your fire to burn out or too low. By so doing you certainly will consume more fuel, allow an inrush of cold air through the dead or low spots into the furnace, make more ash, cause clinkers, and generally it is bad practice. Study the conditions. Cover when the fire is ready, generally when the fire is near or at a white heat. When a fine white ash begins to rise, then is the time, but not always, so watch out. Never do this in a hit and miss fashion that may suit your convenience. The fires and the results are first. Results cannot be obtained in any other way, and the results we must have.

Raking Fires

RAKING or digging a fire is generally unnecessary and must not be done, except in extremes, and neglect will largely cause the extremes and they must be accounted for to us.

Leveling of Fires

THIS is practically the same as raking. Keep the fires level by the proper handling of the shovel. You can do it. The leveling bar is a lazy man's tool, and he simply does with it what he is too slack or incompetent to do otherwise. In either case man or bar is not wanted.

Shaking and Cutting Fires

THERE can be no fixed rule, but it is to be done only when actually needed, and this does not mean to make up for neglect, which will not be tolerated. Shake or cut down when best, but mind that means largely that if fires are properly handled it is unnecessary and not best, except at cleaning times. With

a heavy fire caused by hard running or poor fuel it is best and proper, but this does not cover neglect. Letting a fire down, then heavily covering it will make it necessary, but this must not be done. Poor coal or hard firing will do it. This is a different case, and we know the difference between the two and shall so consider them.

Depth of Fires

CARRY as thin a fire as practice tells you is best, taking into consideration fuel, both as to quality and quantity used, load and weather conditions, which will influence the draft, the length of time the damper will remain open, "the heavier the fire the longer open," the ashes being made. A heavy load will require a correspondingly heavy fire. Too light a one too much air. Study the conditions and govern yourself and the fires accordingly. It will require study and thought as well as fuel. Give the fires both.

Cleaning Fires

DO not raise pressure because you expect to drop it again, or cannot hold it. You can and must. It is a bad practice and no credit to you. Get all ready, now be quick. Burn your fire down, this, of course, depending on the fire and other conditions, but down. Do not load up with a large quantity of fresh fuel to be handled all over and wasted while cleaning. Burn the fire down close.

Coal lightly and as soon as it is well ignited, with hoe draw the fire just away from bridge wall, and push just back from front to prevent waste, then cut as experience tells you is the best way. Generally pushing the lever clear back, rock it ahead to or near central, then back, doing this once or twice, depending on conditions of fire, This will help to soften up fire or break clinkers, if any; then draw lever full front to cutting position, then back to center, dropping the ash to pit. Repeat the latter if necessary. Do all quickly and with the doors closed, damper blocked slightly open to carry off the dust.

Do not cut too close, or so the fresh fire will come down direct onto the grates, which is ruinous as well as wasteful and will kill the live fire by coming into contact with the cold grate, causing clinkers and other troubles. Level the fires quickly with hoe. You need not, in fact it is not best, to be too particular at this time. Cover very lightly all over with fresh coal. Get the doors closed as soon as possible. Then when the fire has burned up and the damper is again closed level with the leveling bar, if needed, but in all cases avoid fussing or digging at fire. Be quick. It is no mark of a good or profitable fireman to be always at work with his fires. The one who sees and works quickly then lets his fire alone to do its part is the successful fireman.

Be continually on the watch. Study your work and the results. It will vary. What will exactly do to-day may not work at all to-morrow. Avoid continually opening your doors to look in. If you watch the conditions you will know what is taking place inside without having continually to look in. Do not be bothered by anyone when your fires or apparatus need your attention.

Generally the wastes at or around the boilers are equal to, or more than, all others combined. In our case cut them out.

Damper Regulator

SO manage your fires to keep the damper closed. It was not put on to see how many times it could be opened or closed. Help it out by doing your part. It alone cannot do the work. Use your head and the regulator will make your work less. In connection with the main damper and regulator, use the hand uptake on each boiler, depending, of course, on conditions as to how much, but use it. The combination of yourself, damper and fire will produce the steam chart and results we want. It can be done.

Ashes

WET them in the pit enough to hold the dust, but not to be sloppy. Take them up as soon after cleaning as possible. Fill cans full, but do not pound them in or overload. What you may save in this way will be taken out of the cans in handling and they cost money. Be fair in loading them evenly so as to get as even an ash percentage as possible.

Feed Water

ALWAYS have a regular continuous feed, not on and off, which produces poor results in every way. Carry 3 or 4 in. of water in glass, and keep it there, not by continually changing the water valve, but by so graduating it that it will carry there. Regular feed is economy. Remember that your boilers if neglected are as deadly as dynamite to all, and the block. Blow the columns regularly and know they are all right. Watch the entire apparatus, as shells, walls, arches, grates, lines, etc., and report on them if anything is needed.

Steam

CARRY your steam steady. We shall expect and require it. Uniform pressures are economy. Variations are expensive as to fuel and ruinous to the entire apparatus. The continual expansion and contraction on the entire apparatus both in the plant and block will in the end cause trouble. It must be avoided.

Fuel

WE shall at all times, to the best of our ability, provide the best and cheapest fuel, and in so doing must ask your co-operation, both in its use and in carefully and understandingly handling and checking it up. We have no pets or favorite fuels. Shall treat all fairly so long as we get the results. We must make it count and know what is being done daily. All work together. Make careful reports and all will be the better for it.

Smoke and Gases

THIS can be largely (almost entirely) prevented by your using good judgment in the handling of your fires. Fire only when a fire is ready and conditions tell you it is the time (this you must learn). One side at a time only. When the damper is closed, if possible, not just as it is to open. In this way the gases from the fresh fuel will be ignited by the live fire and burned in the combustion chamber, the boiler taking up the heat, the gases not going off as unconsumed gas, or the best part being wasted.

No one can tell you all of the kinks which go to make successful firing possible. You must study and watch for results. Note carefully what each change or method produces in results. With different boilers, different conditions, and, especially so, different fuels, you must be governed by the results obtained. Carefully study them, find what is best. Have a system, then follow it. If you do so you will obtain the desired results, and, to be plain, if you cannot get them we must find someone who can.

General Attention

WE have a right and do expect the man, or men, in charge of the boilers or plant to be careful and saving in all ways, both in labor and materials. To give the entire apparatus his careful and strict attention, live up to our rules, work for the interests and favor of the men who employ him. Read and study. By reading we do not mean trash, but books and papers (a school), or something that will elevate and help him to improve as a Man and his Profession. Firing as well as running is a trade and is being more so considered by our best men. Not to be compared with automatic apparatus, which is but a makeshift, and used largely because good men cannot be obtained. The two are not to be compared in any way.

Do not be content to be a "coal shoveler," be a fireman on your way up to a better position. Make room for yourself at the top, then your services will be in demand. The company will do the best it can by you, treat you like men. In turn do your best by it. Do not long expect to stay and give them 95 per cent. worth of work or knowledge for a dollar, any more than you would accept it as your pay. With our combined efforts we can make our plant and the block pay, and a credit to all.

Firing Instructions for Soft Coal

BREAKING up of coal must be done in the coal bin to avoid dirt in the fire room.

Do not overload car.

Bins to be swept and kept clean.

In firing, do not load the shovel full, as it scatters more, which in turn is tracked all over our rooms.

Fire room to be kept clean; swept often and floor flushed often.

Do not fire in scoopfuls in a place, or "pancake fashion," but lighter and by the turning of the wrist to the right or left, scatter or spread fuel lightly, thus giving it a better chance to burn up through without coking hard.

The raking and digging of the fire must be avoided, and it can be done. Break crust only when necessary, but by the proper handling of the fire this can be largely avoided. Remember firing is a trade, requires study, good judgment and your attention.

Avoid the cutting of fire to a red "under grates," as this is in many ways wasteful and unnecessary, overheats grates, wastes fuel.

Keep doors and damper closed all that is possible. Study fuel, and save both in fuel and dirt, as both cost the company money. Use your head as well as your strength. So carry your fire that you will maintain a steady steam line. Even steam and water is economy. These we must have.—The Isolated Plant.

EVERY TIME an accident occurs in a plant the lesson of the accident should be so well learned and heeded that a repetition of the accident will be practically impossible. If the accident was due to lack of sufficient safeguard on the machine, that safeguard should at once be provided. If it was due, as is frequently the case, to the carelessness of the man himself, the other men should be so warned with this specific example before them that the same sort of carelessness will not be repeated. We are bound to have accidents and many of them, but when it is realized that a large proportion—probably two-thirds—are easily preventable by taking proper precautions, the necessity for a string of such occurrences is seen not to exist.

REGULATING FEED-WATER FOR PEAK AND OVERLOADS

IN hand-firing a boiler, especially for locomotives, the water level is purposely raised on the down grades or the light load, and is lowered on the up grades or heavy load. In this way an automatic conserving of energy and the increasing of steam capacity is secured, because a greater amount of water is heated and stored in the boiler during light load, and evaporated during heavy load.

The same kind of regulation by means of a feed-water regulator is now advocated by the Northern Equipment Co., of Chicago, which has developed the method in response to a request of a railroad official for such regulation. The method of connection to secure this result is shown diagrammatically by Fig. 1, the regulator triangle being placed so that the lower end of the expansion tube is at the desired lowest water level shown at the first gage cock in the illustration, and the upper end of the tube is placed so as to be opposite the highest water level desired, shown at the third gage in the illustration.

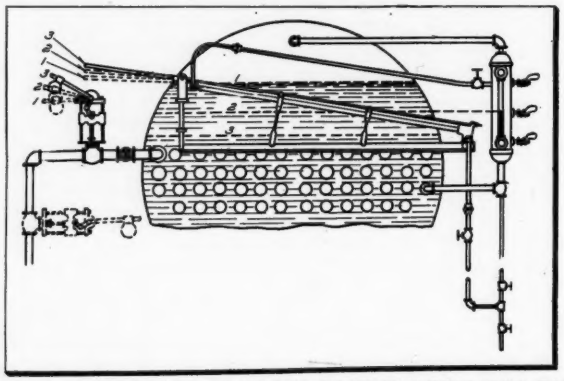


FIG. 1. POSITION OF TRIANGLE OF NECO REGULATOR FOR SUBMERGED TUBE OPERATION

Merely by changing the angle of the expansion tube, the variation in height of water level between no load and full load can be set at a few inches or a foot, as desired to suit the local conditions. The triangle should be placed as near the water column as possible, but not necessarily in front of the boilers as shown. It should always be in position, however, to bring the ends of the expansion tube at the desired water levels.

Briefly the operation is as follows: At normal load, adjustment is such that the regulator holds the control valve open just enough to keep the water at the desired normal level, usually the second gage cock. The expansion tube is then half full of water. Any unusual increase in the demand for steam, lowers the boiler pressure, in turn lowering the boiling temperature of the water and a comparatively large amount of the surface water is quickly evaporated to take care of the overload.

The drop in pressure in the boiler will permit a rise of the knoll of water over the hottest part of the boiler, so that the water level will actually jump upward in the boiler, in the gage glass and in the expansion tube, due to the fall in pressure. This water rising in the expansion tube forces out steam, causes contraction and actually reduces the opening of the valve and cuts down the flow of water just at the instant that the drop in pressure takes place. If the load continues,

the evaporation of water due to the decrease in boiling point will cause a drop in the water level, which allows steam to enter the expansion tube, opens the valve wide enough to take care of the increased load, but no more. With every increase in load, this action is repeated and the steaming surface and capacity increase until the low limit of water is reached, at which point the expansion tube being full of steam reaches its maximum expansion and the control valve is automatically opened to its full area.

With the boiler running at normal load, if the load becomes less than normal, the action is reversed. With the decrease in load, the boiler pressure automatically increases slightly, thus increasing the temperature of the water, forcing the knoll downward and allowing more steam to enter the expansion tube so that the valve is opened a little wider, permitting a greater amount of water to enter the boiler. This continues with dropping of load until the high limit allowable for the water is reached, when the expansion tube is full of water and automatically closes the inlet valve. It

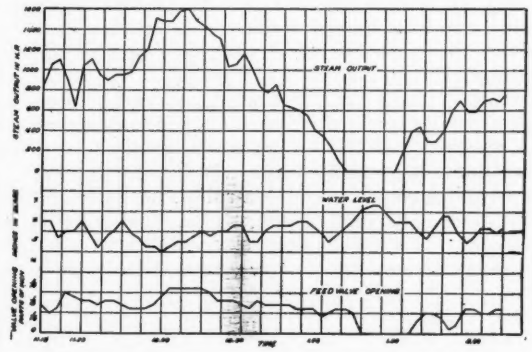


FIG. 2. RESULTS OF TESTS ON CONTINUOUS FEEDING WITH SUBMERGED TUBE

will thus be seen that the control valve is shut only at no load, and wide open only at overload; that greater steam making surface is available at heavy load than at light load, and that heat is stored up during the low load period to be utilized during the period of high load.

Figure 2 shows graphically the results obtained by the Boston Elevated Railway Co., and study of the curves brings out several interesting points. Comparing the curves for load and water level, it will be seen that when the load is high, the water level is low, and the converse is true. The valve is shut only at no load, thus giving continuous feed as long as there is any demand for steam. Also, the steam output responds to every increase in draft and stoker feed, the fuel being furnished by a Taylor stoker which has a mechanical draft control, proportioning the draft to the load.

It has been found that this method of connection produces an increase in pounds of water evaporated per pound of fuel, and, by automatically dropping the water level when the load increases, avoids the making of wet steam during short overload periods. Also when the system is used in connection with a superheater, the effect is such that when a large amount of steam is passing through the superheater, the gas temperature will be sufficient to give as great a degree of superheat at the overload point as with normal loads, a condition which is highly desirable when using steam turbines.

Plants to which this method of regulation is particularly well adapted are those furnishing current for electric railways, steel mills and other industries where the load fluctuates rapidly and widely.

THE CARE OF BELTING

IT may seem trite to assert that the life of a belt depends on the care given it. This is true of almost any article, but it is particularly true of belting, and it is also a fact that although the warning is oft repeated, it is almost invariably disregarded.

In the first place care should be taken in the selection of a belt. There is a certain limit in strength beyond which it is not safe to go, and it is always safer to have a heavier belt than the work requires rather than a lighter. There are many good rules to determine what size and ply to use for certain work.

Then the splice should be made accurately. The ends should be cut straight, using a try square. If lacing is used, the holes should not be nearer to the edge than ½ inch, and care should be taken to lace them straight.

Belts should be put on quite tight and a day or two's running will ease them up. But as soon as they become slack, they should be tightened; yet running the belt too tight is also injurious not only to the belt but to the machinery as well.

Slipshod methods in regard to belting should not be tolerated. It is not uncommon to see boards nailed up to keep the belt running on the pulleys. Methods like these have their effect on belting and the manufacturer suffers from this to some extent, but the consumer is the worst sufferer. Treat your belt as an investment on which large returns in service can be gained if you give it proper treatment. Put it on correctly, splice it straight and true, be careful as to tension, get it large enough and heavy enough, and your reward will be not alone in the life of the belt but in wear and tear on machinery as well.—Sawyer.

THE UNITED STATES CIVIL SERVICE COMMISION announces an examination for junior engineer, for men only, on April 16 and 17, 1913, at principal cities of the country, to fill vacancies in this position in the Water Resources Branch of the Geological Survey. The entrance salaries will range from $1080 to $1200 a year and expenses when on field duty. Competitors will be examined in the following subjects, which will have the relative weights indicated:

Mathematics (algebra and geometry), 5; plane surveying, 10; irrigation engineering, 10; river hydraulics, 25; water-power engineering, 15; and training, experience, and fitness, 35. The scope of the third, fourth, and fifth subjects is covered by the following textbooks: Wilson, on Irrigation; Hoyt and Grover, on River Drainage; and Meade, on Water-power Engineering. Persons who are appointed as a result of this examination will be eligible for promotion to the grades of assistant engineer and full engineer after they have demonstrated their fitness for such promotion to the satisfaction of the Department and the Commission. The salaries of assistant engineers range from $1380 to $2000 per annum, and for engineer from $2400 to $3000 a year. Age, 20 years or over on the date of examination. Persons who desire this examination should apply to the United States Civil Service Commission, Washington, D. C., for Form 1312. In applying for this examination the title—Junior Engineer (Male)—should be used.

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

CONDUIT WIRING*

Suggestions for Selection of Conduit and Fittings and the Installation of Conduit Wiring

By O. N. Casey

THAT conductors can be removed and replaced in conduit is one of the advantages of conduit wiring, but if a size of conduit is selected that is too small for the wires, they will become wedged in, particularly in a warm location, and withdrawal will be impossible. Conduit should always be large enough so that great force will not be necessary to pull wires into it; where too much force is used, the insulation will probably be injured and the wires wedged so that they cannot be withdrawn.

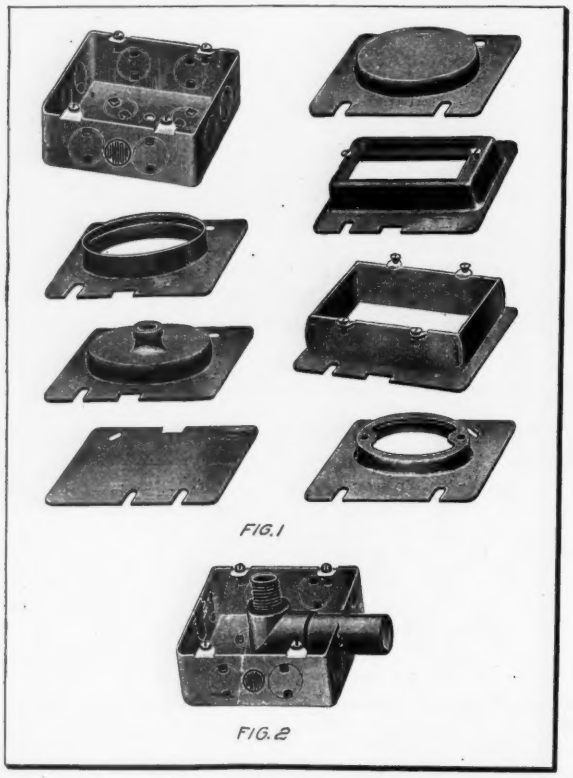


FIG. 1. STEEL OUTLET, SWITCH OR JUNCTION BOX WITH SEVERAL STYLES OF COVERS FOR USE WITH RIGID OR FLEXIBLE STEEL CONDUIT

FIG. 2. STEEL COMBINATION BOX FOR COMBINATION FIXTURES

In selecting a conduit size for the conductors of a 3-wire system with a neutral twice the size of the outer conductors, use a conduit of a size to take 4 wires the size of the outside wires. For example, the conduit for a 3-wire main, composed of 2 200,000 c. m. outside wires and one 400,000 c. m. neutral, should be large enough to accommodate 4 200,000 c. m. conductors. The Code permits but 4 2-wire circuits or 3 3-wire circuits in one conduit.

Conduit containing feeders should run as straight and as direct as possible to the outlets or panel boards; there should never be more than the equivalent of 4 right-angled bends between drawing-in outlets.

Whether the branch conduits shall run in the floor parallel to the lines of the building, or whether they shall run from outlet to outlet in a direct manner across the floor, is a question which must be decided by governing conditions. As a rule, where the flooring is of concrete, mosaic or tile, it is allowable owing to the absence of wooden floor sleepers, to set the conduits to take the shortest and most direct route; this requires less conduit, less wire and oftentimes less work. It is usual, however, to run conduit that lies within floors parallel with the walls of the building; horizontal runs are installed in floors and vertical runs in partitions or walls.

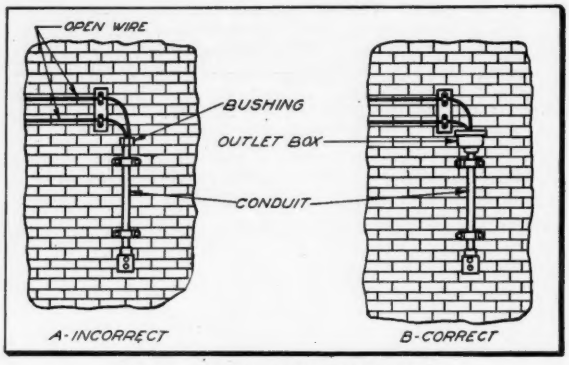


FIG. 3. OUTLET BOX ON CONDUIT

In fireproof buildings the branch circuits are usually placed just above the steel floor girders in the filling between the sleepers, and it is usual to place the conduit just after the ceiling arches have been put in place and the filling leveled with the top of the floor beams.

Floor conduits must be rigidly fastened and, where they are installed on top of the surface just below the floor, staples or hooks well secured in the concrete are used for the purpose. When, however, the conduits are put in directly above the steel floor beams and before the sleepers are down, the concrete and ash filler are sufficient to hold them rigidly in place, although they are also fastened as an extra precaution.

*Continued from page 265, March 1 issue.

Outlet boxes that are used for conduit wiring are of sheet steel, preferably coated with zinc. They not only hold the conduit ends firmly in position and form a pocket for enclosing wire joints, but they constitute electrical connectors between the elements of the conduit system, all of which must be in good electrical contact. Each conduit run in an installation must terminate in an accessible outlet box. Outlet plates are thinner than boxes and are used where the installation of outlet boxes is not feasible.

Conduit outlet boxes are made in many different forms, and covers for them are also made in many different forms, adaptable for special purposes. A steel outlet, switch or junction box is shown in Fig. 1, with several styles of covers.

Where the conduits should enter from the sides or for combination fixture outlet work, the combination box, shown in Fig. 2, can be used, when equipped with a suitable cover.

Two of the knock-outs in the combination box are so formed that, when they are removed, either a round opening for conduit or an oblong opening for pipe is secured. The shallow box, which can be purchased with or without screw lugs for covers, is cheaper than the combination box.

Round boxes are made 3 in. and 4 in. in diameter; the 3-in. size is large enough for ordinary building wiring. Shallow boxes are about ½ in. or ¾ in. deep.

Standard round boxes for installation in brick are about 1½ or 1⅝ in. deep, while those for lath and plaster are about 2¼ in. deep. This depth is necessary to insure that conduits entering the side knockouts will clear the plaster. Square boxes are about 4 in. square and about 1⅝ in. deep for brick, and 2¼ in. deep for lath and plaster.

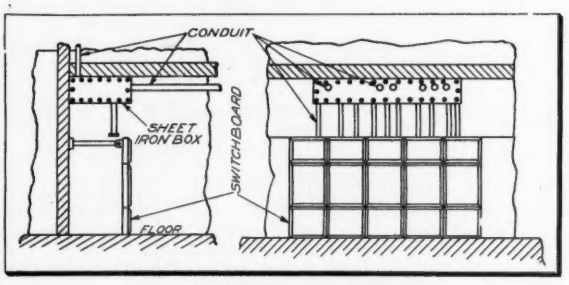


FIG. 4. CONDUIT JUNCTION BOX

All boxes should be installed so that the outer edge of the box, or the cover mounted on the box, will come flush with the surface of the plaster. The cover of an outlet or junction box should never be concealed, as this would defeat its purpose.

Switch outlet boxes for one or 2 switches can be formed by equipping a square box with switch cover; where more than 2 switches are required in 1 group, special outlet boxes for the group can be purchased.

A special bracket, outlet and junction box 3 15/16 in. in diameter and 2 in. deep, is of great convenience where there are many bracket outlets to install, inasmuch as 2 parallel conduits can be run into it as with a square box, but at the same time its diameter is such that a bracket canopy will cover it. A square box with a round-opening cover will accomplish the same end, but the combination will cost more than the special box.

Every conduit outlet should be equipped with an outlet box or plate, to satisfy code requirements. Although inspectors sometimes accept the arrangement of Fig. 3 at A, that shown at B is much better and should be used, inasmuch as it provides the 2½ in. separation required for open wiring when the conductors are not enclosed in flexible tubing.

Conduit junction boxes, which are in reality nothing more than pull boxes on a large scale, are frequently convenient at points where several conduit lines intersect, as, for instance, over a switchboard, as shown in Fig. 4, from which conduit lines radiate. The junction box is usually supported from the ceiling, and is best made of sheet iron on an angle iron frame.

The sides should be held on with machine screws turning into tapped holes in the frame, so that they can be readily removed. Round holes can be cut in the sheet-iron sides for the conduits, or instead, and often preferably, slots can be provided. The conductors can be carried from conduit outlet to conduit outlet, in any direction desired within the box, and the use of elbows and troublesome conduit crossings can, thereby, be avoided.

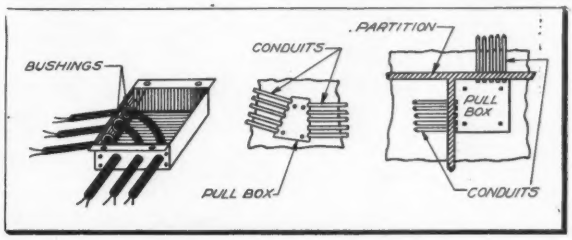


FIG. 5. CONDUIT PULL BOXES

Pull boxes can often be advantageously substituted for elbows, as shown in Fig. 5; large elbows are expensive. Where there are 3 or more right-angle turns in a run, a pull box should be inserted; one pull box may be substituted for several elbows. Wire can be pulled in more readily where there are pull boxes; hence, with them smaller conduit can often be used. Pull boxes can be made of sheet steel or of wood lined with sheet steel. Boxes should be made and drilled in the shop where proper tools are available, rather than on the job. Several types of pull boxes are shown in Fig. 5.

(To be continued)

PROTECTING EXPOSED METAL WORK IN BATTERY ROOMS

IT is essential that no metal work in the battery room, especially over the cells, be exposed to the action of the acid fumes and gases. The structural iron work of the building can be well protected by encasing it with expanded metal work upon which a coating of cement plaster is placed. This, if kept well painted with a good lead paint, will prove a satisfactory way of protecting all structural metal work. Pipes and small portions of metal work can be protected by sheet lead, or if they are not in too close proximity to the cells can be protected sufficiently by frequently cleaning and painting with an acid resisting paint.

One great danger of exposed iron work in a battery room, if it extends over the battery, is that the sulphate of iron formed by the action of the fumes may fall into the cells and impair the purity of the electrolyte, thereby seriously damaging the plates.—Canadian Manufacturer.

ELECTRICAL EQUIPMENT OF A GASOLINE AUTOMOBILE

Ignition, Lighting and Self-Starting Devices, Their Operation and Application

MODERN gasoline automobiles for pleasure purposes use electric lighting and electric self-starting devices to a large extent and an understanding of the principles and operation of such apparatus is essential to those who have the upkeep of machines in charge. The following description of

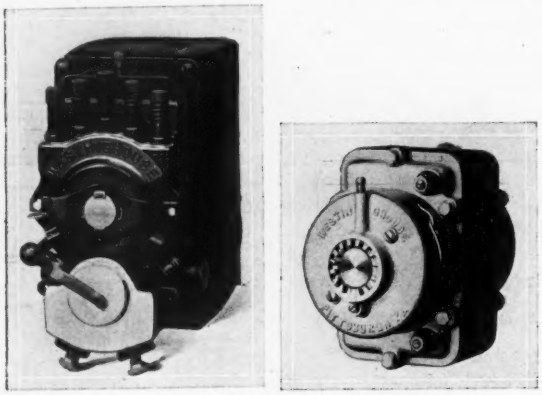


FIG. 1. FOUR CYLINDER AND IGNITION LIGHTING GENERATOR
FIG. 5. STARTING MOTOR

lighting and starting appliances made by the Westinghouse Electric & Mfg. Co. is typical of this class of apparatus.

Westinghouse ignition-lighting system is regenerative, that is, when the engine is not operating or when running at low speed, power for spark is supplied by the battery which in turn is charged by the generator when the car is running at higher speeds. A particularly distinctive feature of this equipment is the single-wire system of wiring, the ground being used as a return.

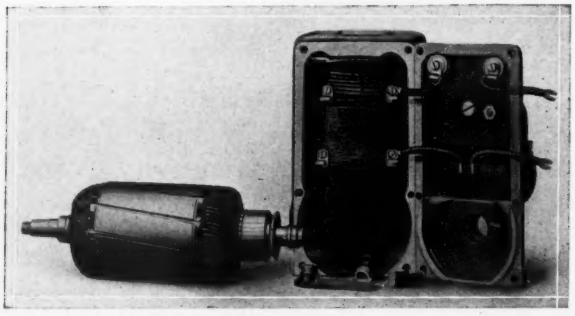


FIG. 2. FRAME AND ARMATURE OF IGNITION AND LIGHTING GENERATOR

The generator is a low speed, steel frame, coil wound machine delivering 6 volts and is connected to the armature shaft, running at engine speed on a 4-cylinder car and 1½ times the engine speed on a 6-cylinder car and it can be mounted in the space occupied by an ordinary magneto.

When the generator attains a speed higher than that at which it generates a voltage equal to that of the battery, a switch inside the generator automatically connects it to the circuit and current flows therefrom to the battery. This occurs at a speed of about 10 miles an hour and is disconnected again at an approximate speed of 7 miles an hour. This difference in speeds is a distinctive feature which prevents the possibility of the switch continually cutting in and out when the car is running at the speed at which it closes.

Voltage control of the generator for the battery is secured by differentially wound field coils; that is, the series and shunt field oppose each other so that as the speed exceeds a certain value, the current in the series coil opposes that in the shunt coil and the voltage is lowered. Regulation is therefore an inherent characteristic of the machine and is accomplished without the use of relays or other accessory devices.

Current for the lights, however, does not pass through the series winding, but as soon as the volt-

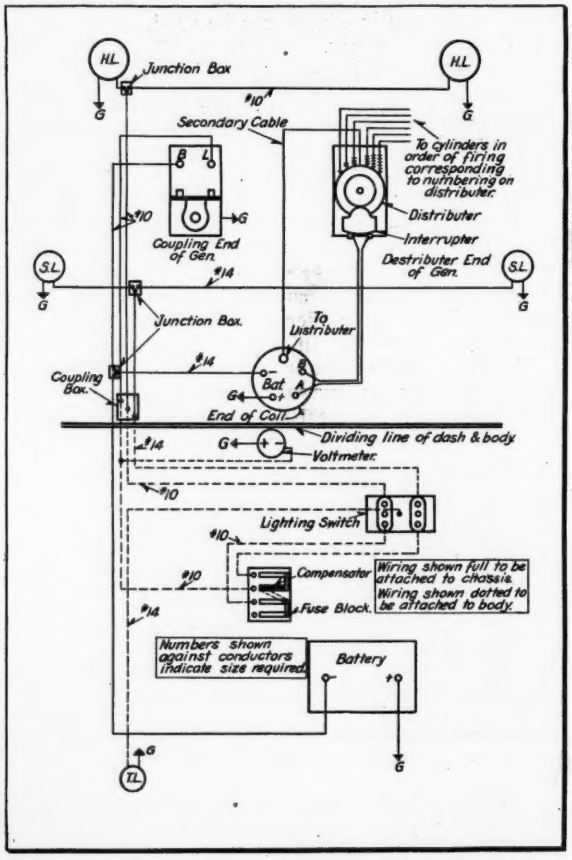


FIG. 4. WIRING DIAGRAM OF COMPLETE IGNITION AND LIGHTING SYSTEM

age of the generator falls below that of the battery, they are switched from the generator to the battery.

Ignition is accomplished through a high-power, single-unit spark coil operating in conjunction with timing and distributing parts on the generator. The battery, either alone or acting with the generator, furnishes continuous power. The timer or interrupter gives automatic spark advance, and also increases the period of contact as the speed increases, to make the spark uniform, regardless of speed.

Starting motors are designed with a view to minimizing the discharge of the battery during starting. This is done by so nicely adapting the power of the motor to the requirements that it turns the engine over as one would do in cranking by hand. This takes

considerably less power than would be required to spin the engine unnecessarily at high speed, and enables the use of a lighter battery and a lighter charging generator because of less capacity for charging.

Motors and generators have ball bearings and steel shafts and frames. They are entirely enclosed, and thus are dust and liquid proof.

FIG. 3. IGNITION COIL AND SWITCH

The motor is started by means of a pedal switch and gear lever combined, this produces low speed which is maintained until the gears mesh and then full speed is attained which turns over the engine. It requires approximately 250 amp. to start the motor, but this, of course, varies with the engine, the motor, as the generator, being wound for 6 v.

LARGE ELECTRIC PROJECT

Electrification of the Melbourne Suburban System of the Victorian Railways

PROBABLY the most notable railway electrification project at the present time is that about to be undertaken in connection with the suburban steam railways of Melbourne, Australia. The advisability of the step has been under consideration for a number of years, and in 1908 Charles H. Merz of the firm of Merz & McLellan, of London, presented a comprehensive report on the subject to the Victorian Railway Commission. In this report Mr. Merz, acting as consulting engineer on the scheme, went fully into the whole question of the substitution of electric traction on steam railways.

Since that time a number of important railways have been electrified in all parts of the world, and experience has demonstrated the great advantages and economies which result from this mode of operation. In this particular case, the rapid growth of the suburban business in and out of Melbourne was also a decisive factor that emphasized forcibly the need for electrification. Recent practice especially has shown that the adoption of the high voltage direct-current system by a number of roads has resulted in eminently successful and exceptionally economical operation both for suburban and through service.

In a later report, embodying a comparative analysis of the merits of both the single-phase alternating current and high-voltage direct-current systems, based on the tenders submitted, Mr. Merz points out that the adoption of the high tension direct-current system for this application would mean a saving of about $3,500,000, or nearly 30 per cent, in the cost of installation over that of the single-phase system. Accordingly, in view of this initial saving and a further operating economy, as indicated by Mr. Merz, of about $350,000 per annum, or nearly 28 per cent, he recommended strongly the adoption of the high-tension direct-current system for the Melbourne Railways and the Victorian Government accepted his recommendation.

Melbourne, the capital of the State of Victoria, is situated in the southern part of eastern Australia on the Yarra River, eight miles from its mouth at the head of Port Philip. The river is accessible for vessels drawing 22 ft. of water, and all larger vessels are easily accommodated at Port Melbourne in Hobson Bay. Along the river are large docks, shipyards, foundries and manufacturing plants representing a number of industries. The city has a population including its suburbs of over a half a million, and is the most important municipality and the greatest trade emporium in Australia.

The electrification of the Melbourne Suburban Railways is of exceptional interest because it will be one of the largest projects of its kind in the world, involving heavy rolling stock equipment with overhead collectors. The magnitude of the undertaking from the standpoint of equipment and service may be compared with that on the third rail electrified section of the New York Central Railroad out of New York City, and ranks with the Oakland, Alameda & Berkeley electrification of the Southern Pacific Railroad at San Francisco.

Naturally, the great size and tremendous importance of the project attracted world-wide competition, and after an exhaustive study and consideration of the relative merits of the several propositions, Mr. Mertz approved in his report the recommendations of the General Electric Co. of New York as to choice of system and economical features of operation, and the Victorian Government awarded this company the contract for the rolling stock apparatus equipment, comprising 400 motor car equipments, consisting of 4 motors each; 800 control equipments, 400 of which are for trailer cars, and 400 air compressor equipments. This is the largest single order ever placed for electrical railway apparatus.

Details of Equipment

THE mileage of the suburban lines included in the scheme is made up of 150 route-miles, or 289 track-miles of running roads, and 34 miles of sidings. The potential selected for this direct-current system is 1500 v. Power will be supplied from a central station at Yarraville, a suburb of Melbourne, in the form of three-phase alternating current at 25 cycles per second and will be transmitted at 20,000 v. to 12 substations at various points on the system, where it will be converted into the operating direct current of 1500 v. The high-tension transmission is by underground cables from the power house to the important substations in the central area, and by overhead wires erected on the same structures which carry the railway track conductors, to the outlying substations. Overhead conductors will be used throughout the system for supplying current to the trains, which will be equipped with roller pantograph collectors. The complete equipment of the railways involves the expenditure of $12,000,000 in round numbers, and Mr. Merz figures the saving of electric operation will amount to about $600,000 in 1915 over the former steam operated lines.

Normal trains, weighing about 180 tons, will consist of 2 motor coaches and 2 trailer coaches. The tracks are 5-ft. 3-in. gage. The suburban traffic amounted to 70,000,000 passengers in 1908; the figure the past year exceeds 90,000,000; and in 1917, when it is expected that the conversion to electric operation will be entirely completed, it is estimated that the suburban lines will carry 150,000,000 passengers per annum.

The motors, numbering 1600 in all, which will be installed in the 400 motor coaches, will be of new design throughout and will embody the most modern developments and will be provided with commutating poles. They will be rated 140 hp. at 725 v. and will be operated 2 in series on 1500 v.

The method of self-ventilation which will be incorporated in the design of these motors will assure exceptionally effective and uniform cooling. This will be accomplished by a broad-bladed centrifugal fan cast integral with the pinion end armature core head. Fresh air is drawn into the interior through a screened opening on the upper side of the motor frame at the pinion end. This is circulated over the armature and field coils, under and through the commutator, through longitudinal holes in the armature core, and thence exhausted to the exterior through openings in the pinion end bearing head.

The 800 control equipments for both motor and trailer cars will be the Sprague-General Electric Type M relay-automatic control and do not require description. They provide for multiple unit operation and control of the train from the platforms of any motor or trailer car. Type M control has been in operation on heavy traction work for many years, notably on the subway and elevated divisions in New York and other large cities, and has demonstrated its simplicity, low maintenance and reliability.

CENTRAL STATION VS. ISOLATED PLANT

By J. Case

THERE are some advocates of the central station being allowed to supplant the isolated plant, especially for the summer months, the idea being to run the isolated plant in winter when heat is needed, and in the months that heat is not used, shut the plant down, and buy current from the central station. They will tell you that the service is better and cheaper, and many other things that sound plausible to the uninitiated, in favor of their service.

I have in mind one building in which central station service is used during the months of July and August,

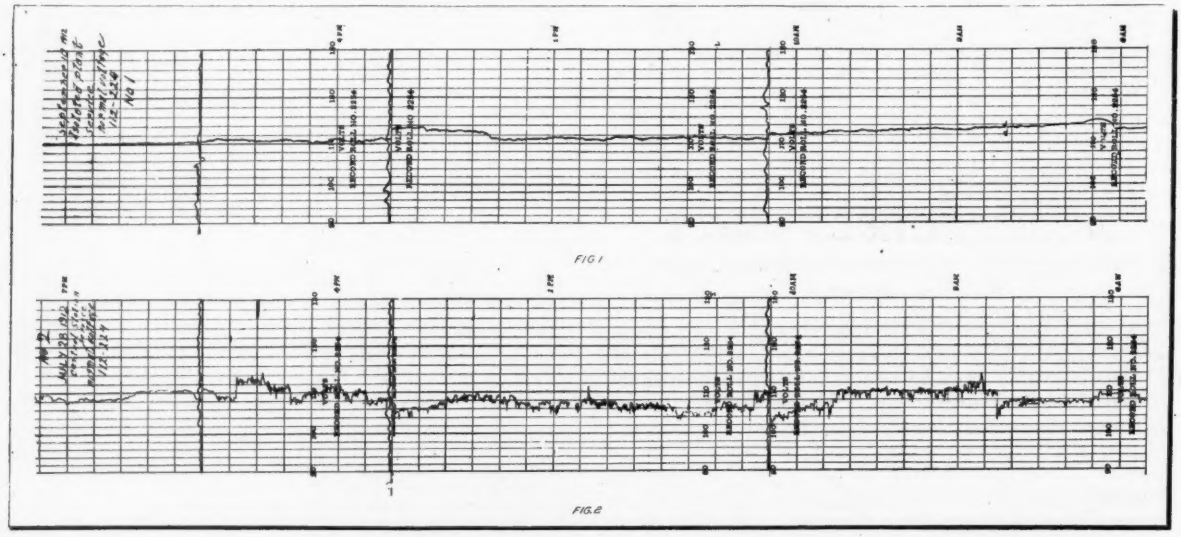


FIG. 1. TYPICAL RECORDING VOLTMETER RECORD OF ISOLATED PLANT VOLTAGE TAKEN SEPT. 10, 1912
FIG. 2. NORMAL VOLTAGE RECORD IN PLANT USING CENTRAL STATION CURRENT, TAKEN JULY 28, 1912

Service on the lines calls for both local and express schedules. The motors will therefore be arranged for tap field control, which will allow a free running speed of 52 miles an hour over level track for the suburban cars on express runs. This method of auxiliary control was introduced by the General Electric Co. a number of years ago, but due to commutating limitations of earlier motors, it was eventually abandoned. Its successful application to commutating pole motors is therefore modern.

The principal advantages to be derived from tap field control are increased operating efficiency, continuous saving of power, economy effected through decrease in the weight of the equipment and an increase in the service capacity. The practical effect of tapping the field is to eliminate one resistance step and to secure the desired accelerating effort throughout from start to full speed with a lower current input.

and the isolated plant run the rest of the year. There is a private circuit consisting of 2 750,000 cir. mils, and 1 250,000 cir. mils cables direct from the sub-station which is located 3 blocks away to the building switchboard. The system in the building is direct current 3-wire, the normal voltage being 112-224 volts for use with 110-114-volt high efficiency tungsten lamps and 220-volt motors. The average load from 8 a.m. to 7:30 p.m., is 425 amperes, and the 24-hr. load is about 1100 kw.-hr.

The plant generators are 3-wire, compound wound and run in parallel, and the recording voltmeter chart No. 1, is a fair sample of the voltage regulation on one side of the system. There are 2 voltmeters one on each side of the line. The chart No. 2 is a fair sample taken by the same meter with central station current in use, but with a smaller load as many lights, fans and other motors are not used in attempting to keep the current used at a minimum and consequently hampering the

workmen a great deal. The cost of the isolated plant current is 2.7 cents, and that of the central station service is 2.5 cents to which must be added 2.4 cents overhead charges on the idle plant and men retained.

In this case it has been found by practice that the unsteady central station service makes the elevators work unsteady, also the high efficiency lamps give much trouble by burning at times at a dull red due to low voltage, and at other times much above what they should and for a service in which the best, even light is essential.

There are many other things that make central station service undesirable where good service is essential, and which can only be had through isolated plant service. It might be well to mention here that the isolated plant service has been interrupted once during 3½ yr. and that was for 2 hr. due to a broken valve on the header, and there has been no repairs to make that could not have been done while running the plant.

ELECTRICAL CORRESPONDENCE

SYNCHRONOUS MOTORS; ELECTRO-MAGNETS

WHEN a synchronous motor has a direct-current exciter for its fields, and the motor is started from the alternating-current side through an auto-starter, what causes the motor to start before the direct current can be generated to excite the fields?

2. When starting up such a synchronous motor, should the switch connecting the exciter to the motor fields be open or closed?

3. What is the difference in construction of an electro-magnet used on alternating-current from one used on direct-current apparatus?

B. A. T.

A. A synchronous motor on polyphase circuits starts as an induction motor by reason of the fact that the armature current sets up a rotating field which reacts on the field magnets of the motor, causing rotation.

2. When starting a synchronous motor the field switch should be left open until the motor is in synchronism.

3. An electro-magnet used on alternating-current circuits employs a core built up of either soft sheet steel or iron, otherwise its construction is practically the same as a direct-current magnet. N. G. M.

ELECTRICAL ENGINEERING PROBLEM

REFERRING to the question under the above heading in Practical Engineer, page 241, Feb. 15 issue, I submit the following solution to the problem:

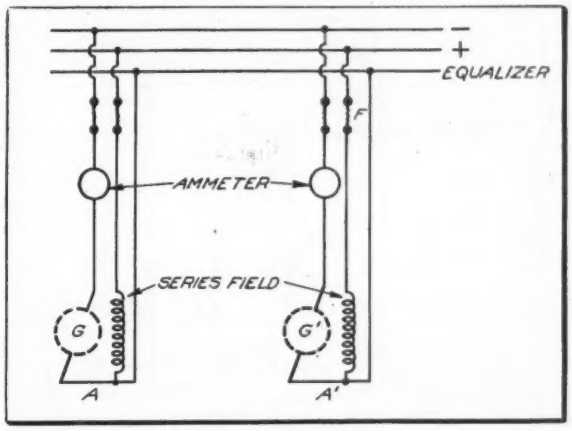
When operating compound-wound generators in parallel it is necessary to connect the brush, to which the series field is connected, as at A, to the corresponding brush on the other machine, as at A'. This is usually, but not necessarily, the positive brush. It is essential that all machines operating on the same buses have their series fields connected to brushes of like polarity.

The connection, from A to A' is usually made through an auxiliary bus, which is known as an equalizing bus; this bus is not absolutely necessary, however, and sometimes the connection is made by means of a direct line which does not touch the switchboard.

The function of this line is to equalize the load on all machines which are operating in parallel. Now let us see how this is done. If we wanted to increase the load on one machine we would do so by cutting resistance out of the shunt field circuit, by means of the field rheostat, not shown in diagram, thus increasing the voltage, with a corresponding increase in the load.

Now assume the shunt field on the machine G to be stronger than on G', the result is a higher potential at the point A than at A'. Current flows from a higher to a lower potential, and consequently will flow from A through the equalizer to A', thence it must pass through the series field winding of the machine G', thus increasing the field of that machine, with a consequent rise in voltage and load, thus bringing the load on this machine up to that on the other one.

Now to go to the case presented by Mr. Scott. He says a positive fuse was blown, as shown at F in the diagram. The puzzling part was that with this fuse gone the machine G' continued to deliver 150 amperes. This, however, ceases to be a puzzle, when we refer to the diagram, for it will be seen that this current had a circuit from A' through the equalizer to A,



GENERATOR CONNECTIONS

thence through the series winding on the machine G to the positive bus. On returning over the negative lead it passed through the ammeter and was registered up to the machine in which it was generated, just the same as though no fuse had been out and it had taken its regular course.

This machine did not deliver its full load with the fuse out, simply because its series field was cut out and it was operating as a shunt machine.

J. M. Row.

Editorial Note

WHEN considering this problem the question arises, why didn't generator G' mortize? It naturally would be supposed that this would be the case when G' lost the excitation due to the series field winding, but as the ammeter needle did not reverse it is evident that it must have continued to generate.

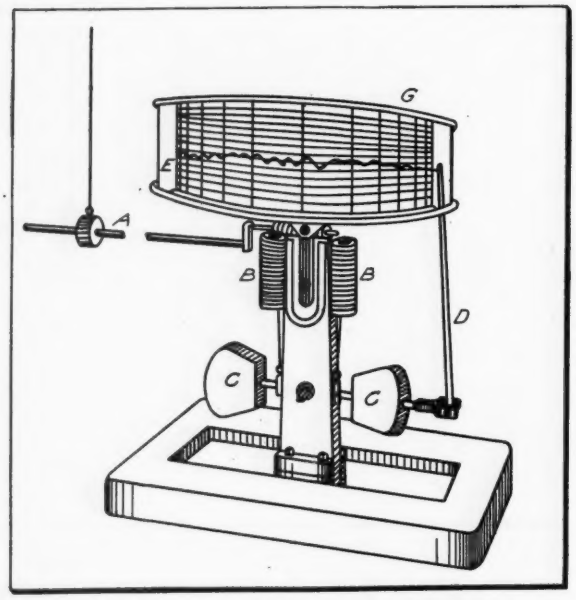
It is reasonable under these conditions to assume that the series shunt was of such low resistance that only a comparatively small percentage of the current generated by the machines passed through the series windings, therefore when G' lost the series field excitation the voltage was not naturally lessened.

FOREIGN DEVELOPMENT IN THE POWER PLANT FIELD

Load Indicator for Steam Engines

By J. H. Blakey

IN the Zeits, des Ver. deutsch. Ingen., M. Boetcher describes a load indicator for steam engines which is adapted to all types of motors, both reciprocating and rotary, and which registers the load in terms of time. The apparatus is of simple construction and consists of a horizontal lever in neutral equilibrium, connected on the one hand to the sleeve of the regulator, every movement of which corresponds to a determined load on the engine which it governs, and on the other hand to a tracing point which rests on a revolving drum. It has been necessary, however, to complete it by a deadening arrangement which prevents the transmission of the rapid movements of the sleeve about its position of equilibrium after each one of its displacements.



LOAD INDICATOR FOR STEAM ENGINES

The apparatus is shown in the illustration. The lever is loaded with 2 counter-weights C and C, balancing each other and designed to increase its inertia. It is connected to the lever A, which is actuated by the regulator shaft, by 2 springs BB, which have the double function of relieving the lever bearing of its weight and deadening the short oscillations of the lever A. The movements of the lever C are communicated to the tracing point by the arm D, and the paper E, on which the variations of the load are registered, is fixed on a drum revolving by clockwork.

Smoke Washing

THE crusade against smoke has been carried on for many years in England. At a factory in York there is an installation for smoke prevention which has been in operation for a considerable time. The method consists in the washing of the gases before they pass into the chimneys, the washing having for purpose and result the complete carrying off of the soot, dust and sulphurous acid. The gases of combustion first traverse chambers called "economizers," which permits the utilization of part of their heat to warm the feed water for the boilers. Then they pass into a washing chamber, which is of brick construction containing baffle plates of cast iron. Into this chamber spurt a number of jets of water, and at another point there are curtains of water; some of the jets are warm water and some cold. The warm water is brought from the economizers and has the effect of saturating the smoke with water vapor, which facilitates the washing down of the soot and dust by the cold water. The deposits formed on the floor of the chamber are carried off by a flow of water proceeding from cisterns with an automatic discharge and received in tanks situated parallel to the washing chamber. For 2,400,000 cu. ft. of gas an hour from 1100 to 1340 cu. ft. of washing water are required.

Lubrication for Bearings

AS a lubricant for bearings supporting heavy loads, the "Revue General de Chimie" recommends the following:

Heat for one hour at 140 deg. F. 375 parts by weight of petroleum, 125 parts of beeswax, 60 parts of caoutchouc, 50 parts carbonate of soda, and 60 parts of powdered graphite.

Heat Treatment for Steels Low in Carbon

REVUE de Metallurgie for July, 1912, gives the results of experiments which have been made on 2 steels containing respectively 0.35 and 0.34 per cent of carbon, 0.63 and 0.60 per cent of manganese, 3.15 and 3.50 per cent of nickel, after heat treatment in various ways. Three pieces of each steel were heated up to the required temperature, between 1100 and 1800 deg. F. which was maintained for 2 hr., after which time one bar was quenched in oil, another cooled in the air, and the third allowed to cool down with the furnace. Generally speaking, the oil quenched specimens showed the highest elastic limits, tensile strengths and contractions, and the slowly cooled bars showed the lowest values. The most suitable temperature appears to lie between 1470 and 1560 deg. F., which is well above the critical temperature.

The Effect of Oils and Greases on Cement and Concrete

THE action of oils and greases upon cement, mortar and concrete is interesting on account of the necessity of saving structures in concrete from deterioration, as far as possible. Chemically this action consists of the saponification of the greasy matter of the oil; practically, it manifests itself as a disintegration of the coating of cement or mortar. Numerous experiments, notably those made by Schumann, have shown that heavy oils exercise an injurious effect upon the lime of concrete, which effect is greater in proportion as the mixture is poor and lacking in age. The most active oils are those of animal origin, the vegetable oils having less effect and the mineral oils least of all.

The alteration is a saponification of the lime which is found free in the cement; it may be counteracted therefore by an extra thorough mixing of the materials composing the concrete, and by using such a proportion of cement as will prevent its being porous. Structures which must be in contact with oil, such as

the foundations of machines, locomotive pits, reservoirs for storing greases or greasy materials, etc., should therefore be constructed of a cement which does not contain free lime, and the concrete should be made very carefully, with a large proportion of cement. In preference, silicious cements should be employed, as they are more stable.

When concrete containing free lime must be used, some material should be added which has the property of rapidly fixing the lime in such a way that the whole structure will more quickly become solid and permanent. The material which is most easily employed for this purpose seems to be pozzuolan cement, finely pulverized. This contains a large proportion of active silica, which has the property of saturating the free lime and so preventing or retarding its degradation. This is always used in the case of structures exposed to the action of the sea.

The author has experimented with concretes of a proportion of 1 to 3, some containing pozzuolan cement and others not. Certain specimens were immersed in oil during 14 months; they were then examined and tested. The oil in which they had been kept was thick, with a deposit; while the same oil, placed in a glass vessel at the beginning of the experiment, remained perfectly clear. The specimens containing a proportion of pozzuolan cement had nearly the same resistance as those preserved in water during the same time, but those not containing the pozzuolan had a resistance averaging about 20 per cent less than the others. The quantity of pozzuolan varied from 0.1 to 0.2 of the quantity of the sand.—Giornale del Genio Civile.

MISDIRECTED ENERGY

A Midnight Escapade of a Power Plant

By J. H. P.

IT was a dark and stormy night—yes, I know this sounds familiar and melodramatic and should properly be accompanied by weird, shivery music; but the only music we have on hand for this setting is the prosaic flapping of swiftly running belts, the monotonous hum of 2 out-of-date single-phasers, and the rhythmic slapping of dash-pots as the little 11 by 24 Corliss cut off at ¾ stroke. But inasmuch as we started with the intention of keeping this piece of fiction within the bounds of possibility the opening statement will be right and proper.

It was a dark and stormy night, and the long swirls of driven rain beat gustily on the window pane (sounds like Walt Mason). The brilliant interior lighting made the darkness outside all the more apparent, but if one peered steadily outward through the windows, flickering and unsteady lights could be distinguished through the gloom, scattered at street corners here and there in the thriving little city of P———.

P——— boasted a population of 8500, a few small industries and an electric and power plant which furnished current to a single-track street railway, as well as to the town at large, more or less fitfully.

By "fitfully" we mean on those occasions when the boilers started to prime and the engines began to pull water over, or an exciter belt broke, or the once-but-not-any-more insulated primaries got together in the trees on wet, windy nights, or for any other reason, as any central station man knows by heart. The P——— electric light plant was owned by capitalists in a large city who put the property in charge of a local manager who worried along as best he could with the bunch of junk, called machinery, at his command. His troubles were manifold and multiform, but the owners kept jollying him along, telling him what a snap he had and possibly some day if he got enough business they would buy him some more machinery,—second-hand.

The people of P——— tolerated the light plant, just tolerated and very little more, threatening periodically to build a plant themselves to light the streets if the lights were no better, but up to the present time threats were the extent of their actions. Still, one can never tell what a city council will do.

On the night in question the time was midnight, and the storm had continued unabated since early in the evening. The night engineer rose from his seat in front of the switchboard, brushed the crumbs of his supper onto a paper which he placed on the floor before the hungry but patient feline, called Dr. Cook; made a tour of all bearings, inspected the water level in the separator over the high-speed automatic, took a look at the voltage, twisted the field rheostat handle of No. 2 slightly, read the totalizing integrating wattmeter, returned to his desk, put down the hourly reading, sighed and reached in the drawer for the perfecto that an oil salesman had forced on him early in the evening.

"Well, it looks as if we were going to pull through tonight in good shape," said the fireman who had come in from the boiler room, one grimy hand clutching a generous slice of home-made pie.

"Better keep your fingers crossed while you're prognosticating," replied the engineer. "I remember one time———"

A flash of light, a stunning report, and the little 10 by 10 began to speed up until the tardy governor weights advanced the travel of the valve. The engineer stepped to the board, lowered the voltage, closed the circuit-breaker and began to look around on the floor for the 2 ⅞-in. hex nuts which were used to weight the circuit-breaker, thereby augmenting its capacity, and which had to be hunted for every time it opened up.

"Betcha don't find 'em for 10 minutes," jeered the fireman, looking at the clock.

"Bet if I don't find them I know where there are some more," grimly retorted the engineer, going to his desk to get his glasses, and added, "I think that pump has stopped again." Whereupon the fireman disappeared in the direction of the fire-room, leaving in his wake a collection of lurid adjectives pertaining to all 4 by 6 by 4-in. boiler-feeds in general, and one in particular.

(To be continued)

A NEW STYLE MILL refuse burner is being erected by a sawmill owner on False Creek in Vancouver. It consists of 2 steel jackets, one inside the other, with the intervening space of 2 ft. filled with water. This double jacket extends to a height of 72 ft., while above that for another 80 ft. the shell is single. The top is covered with 2 layers of fine steel wire mesh. As constructed this burner insures the refuse being consumed to a fine ash and prevents any possibility of an escape of sparks, burnt sawdust, or refuse. The water jacket does away with the customary lining of fire brick, which it is claimed is more or less of a trouble and expense in a burner of this kind. The burner is 40 ft. in diameter and rests on a concrete foundation.—Canadian Manufacturer.

GAS POWER APPARATUS

Producers, Engines and Industrial Applications

HEAVY MODERN GAS ENGINES

Features of Design and Cost of Operation. Effect of Igniter Location

THE trend of power engineering is directed not only towards fuel economy, but also towards reliability and small cost of attendance. Reliability often means more than extreme fuel economy, because shut-downs and high repair costs are more expensive than a few cubic feet of gas. In other words: If high economy has to be bought at the expense of complicated valve gears with many parts, then it is not a good investment; it would have been better to sacrifice a small fraction of that fuel economy if by so doing the engine can be made rugged.

furnish the only means of regulation; and so efficient are they that the engine runs with the same steadiness for any load whatsoever and for any sudden change of load. Fig. 1 shows the queer shape which the valve assumes for perfect regulation. In this case, theory and practice agreed perfectly, because it has not been possible in practice to improve upon the shape laid out on the drawing board from theoretical considerations.

Should this valve from any reason (tar, grit, gum, etc.) become clogged and sluggish, it can be pulled out easily while the engine is operating on the other

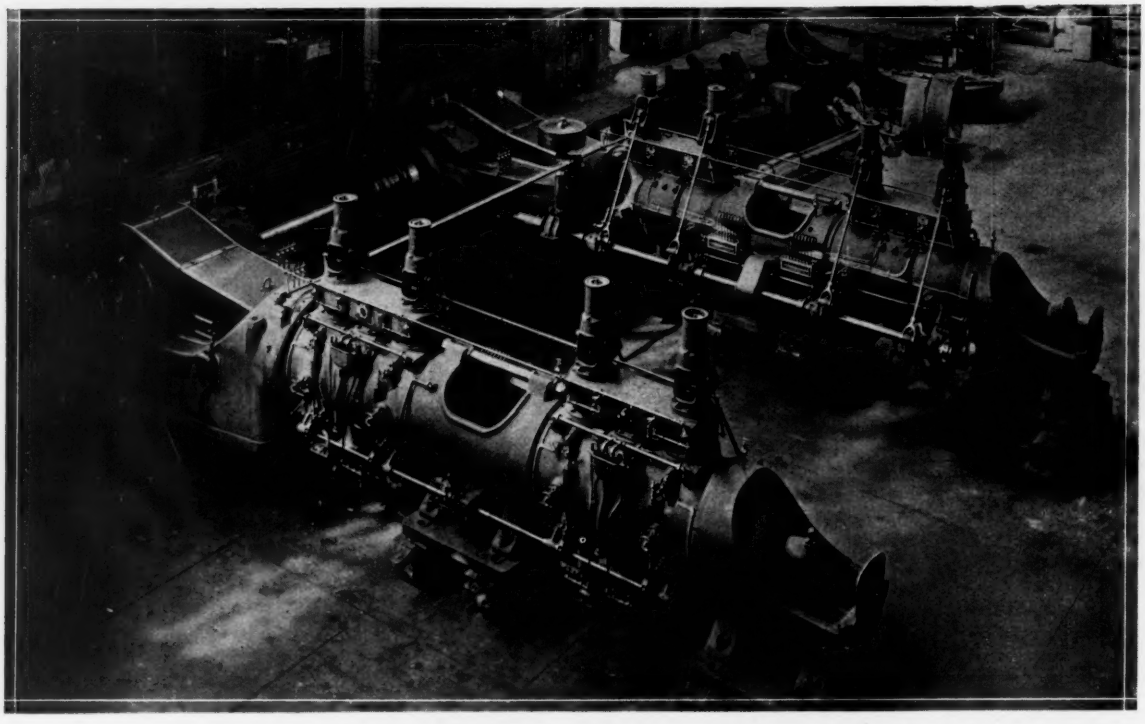


FIG. 2. LATEST DESIGN OF MESTA ENGINES ON THE ERECTING FLOOR

Engines shown herewith, built by the Mesta Machine Co. of Pittsburgh, Pa., have, of course, the usual features of self starting by compressed air, safety control against overspeeding, mechanical make and break ignition, automatic lubrication, etc.

Operation with small cost of attendance has further been made possible by an extreme simplicity of valve gear; without trips or oil relays; there are no cams; just one eccentric for each cylinder end. Cylindrical throttle valves of the butterfly type for gas and air

cylinder ends and can be cleansed without a shut-down. For this purpose an additional gas valve is provided for each cylinder end.

Two igniters are provided per cylinder end. In the latest design, Fig. 2, they are located away from the valve gear side, so that the engineer can take them out and inspect them while the engine is in operation, without fear of being caught in the valve gear.

The location of those igniters has its funny side. It will be seen on the pictures that one igniter lies

above the center of the cylinder, whereas the other one lies below the center, immediately above the exhaust chamber. It has been stated that this igniter is located in the exhaust gases, does no good and might as well not be there.

"The proof of the pudding is in the eating." Acting upon this principle, the engineers of the Mesta Machine Co. decided to test the capacity of one of their engines, when operating on the lower igniters only, until it would not carry any additional load.

FIG. 1. SPECIAL DESIGN OF BUTTERFLY THROTTLE VALVE FOR REGULATING MESTA GAS ENGINES

The engine, which is rated at 400 kw., began to show signs of distress at exactly 300 kw., which furnishes proof that the bottom igniters are certainly not quite useless.

After the test somebody suggested to test the engine in the same manner on the upper igniters alone, and behold, the engine only carried 305 kw. This test more than ever convinced the engineers of the Mesta Machine Co. that their design is right.

Facts are more convincing than theories. For this reason a few operating records will here be given.

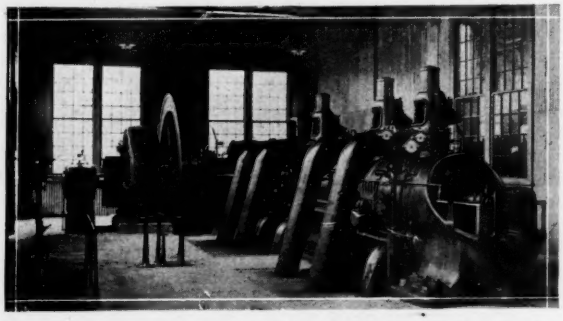


FIG. 3. 400-KW. MESTA GAS ENGINE, EXHAUST SIDE

Eighteen months operating record of a plant

(1) Gas	$5475.00
(2) Labor of engineers and wipers	2340.00
(4) Repairs	480.00
(5) Cylinder oil	218.00
(6) Engine oil	54.00
(7) Waste	45.00
(8) Cup grease	2.43
	$9596.43
Kw.-hr. produced	2,340,000
Hr. in 18 months	13,000
Hr. operated in 18 months	12,420
Cost per Kw.-hr	0.41 cts.

The number of hours of operation compared to the total number of hours available in 18 months is of interest.

The cost of operation per kw.-hr. (exclusive of interest on first investment) namely 0.41 cents per kw.-hr. (with 12½-cent gas) certainly is low, when it is realized that a large part of the waste heat of the engine is utilized for heating water for washing and house warming.

The fuel cost is higher than that derived from test records. But test records do not mean much, because they are usually taken for full load and prime conditions of the engine, whereas in this case the load was often quite light, particularly at night, and the demand for continuous power did not allow the engine to be kept in first class shape all the time.

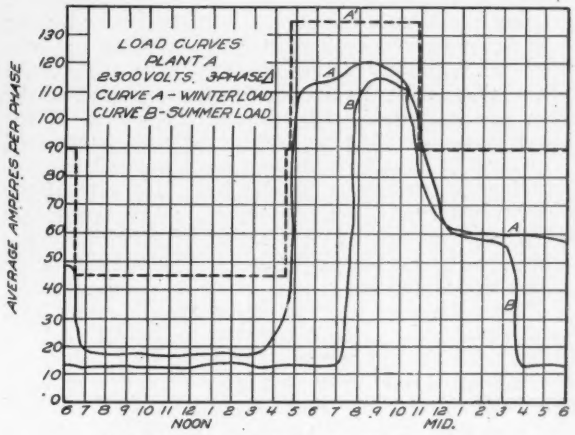
If there is room anywhere for an engine indicator, that place is the gas engine. Igniter points will wear off, and best capacity and economy can be maintained only with correctly adjusted igniters. Their adjustment is best tested by the help of an indicator rig which allows the taking of cards at any time without shut-down. Upon this principle the engines here shown are equipped with an indicator rig which can be thrown in and out of operation while the engine is running.

GAS ENGINE DATA

Some Figures from the Actual Operation of Medium Sized Engines on Central Station Load

By Daniel Roesch

THE plant consisted of 3 generating units, furnishing 2300-volt current for distribution in a town of 30,000 population, the load consisting of series arc lamps for street lighting, commercial lighting of stores, theaters, and residences, and a small day load of motors in sizes from 15 hp. down. Two generators were of 180 kw. rated output and the third 150 kw. These were belt driven by a gas engine operating on natural gas, the 180-kw. machines running from an 18 by 22-in. 3-cylinder vertical type gas engine, and the 150-kw. generator from a 19 by 25-in. tandem



CURVES OF SUMMER AND WINTER LOAD

single acting, horizontal engine. The vertical engines ran at 200 r.p.m., and the horizontal at 175 r.p.m.

For the larger units, the generators and engines were nicely balanced, but in the smaller unit the generator capacity was considerably below that which the engine could care for, so that the limiting load was usually reached by overheating of generator windings before the engine had reached its greatest output.

When the power factor was low, the same conditions prevailed in the larger unit, low power factor being caused principally by the series-arc light portion of the load.

Auxiliaries in the plant were motor-driven, water-circulating pumps for the engine jackets and reservoirs to recool the water. For starting up, ignition current was taken from set of primary batteries, and for running from the exciters of the main generators. Air at 200 lb. pressure for starting was furnished by an independent air compressor, belt driven from a 3-hp. gas engine.

Transformers were used for stepping down the 2300-volt current to 115 volts for house lights and 230 volts for the motors in the power house, and constant-current transformers to change the constant potential current supplied by the generators, to 6.6 amp. constant current for the arc lamps, each constant current transformer taking care of from 40 to 55 enclosed carbon arc lamps connected in series. These transformers were later replaced by 8 more modern direct current arc lamp sets, which gave a more efficient lamp, but a somewhat lower power factor to the generator circuit. This cut down the capacity of the generators and made it impossible to load the engines to the maximum, therefore cutting down the efficiency of the plant. Synchronizing was done with lamps which method proved entirely adequate because of the elasticity of the belt connection between the engine and the generator. If a unit was thrown on the bus bars when it was slightly out of step, there would be a flutter in the 24-in. belt and the rotating armature of the generator would jump into step with little disturbance.

Feeder System

ALL generators fed to either one of 2 sets of bus bars and from these, 3 double-throw oil switches closed the circuit from either set of bus bars to 2 commercial feeders and one arc feeder. The 2 commercial feeders led into different parts of the town, and provided a means of keeping part of the town in current should trouble occur on the lines. The arc feeder led to the mercury rectifier set in the power house and from there to the various arc circuits. Each feeder was provided with an integrating kilowatt-hour meter, the sum of these meters showing the entire output of the plant at the switchboard. Current consumed in the power house for lighting and power was determined from time to time by checking with a small low-potential watt-hour meter on the secondary side of the house transformers. For supplying low-pressure steam to heat the building in winter, and for emergency gas light in the power house, the gas was passed through a station gas meter and was charged to the engines.

Figure 1 shows the winter load and summer load for this plant, the curve A showing the actual loads on the switchboard instruments during 24 hours of winter and the dotted line A^1, the available generator capacity that is operating, the vertical portions of the dotted line indicating the cutting in or out of the units to suit the load.

Cooling Pond

WATER cost about 60 cents a thousand cubic feet and as this amounted to quite an item, a cooling pond was decided upon and was tried with earth banks and bottom in May and June, 1910. The effect on water consumption was so gratifying that this was enlarged to a reservoir 50 by 75 ft., and 6 ft. deep with concrete walls and bottom, which was put in service about September, 1910. A system of 12 spray nozzles and a circulating pump completed this portion of the equipment and proved to be money well invested. Nozzles of the adjustable kind were used as commonly found on the end of a garden hose, and when set to spray a fine mist on the pond were found well adapted for the work.

Loading

THE records showed that engine No. 1 operated 665 hr., during January, 1911 out of a possible 744, or 89.3 per cent of the elapsed time, and in February ran 612 hr., or 91.1 per cent of the elapsed time, these runs representing an average of close to 22 hr. a day with no exceptional wear and tear on the units. Under these conditions of operating one unit at full load would have developed more kilowatt-hours than the total output of the plant, but under the actual load conditions of the plant, that is, low day load with heavy peak during the evening it was necessary to have three times this capacity operating every night during the week with the exception of Sunday night. (This plant would have seemed an ideal place for the use of a storage battery to charge during light load and assist during peak load. Editor).

It will be noted that the lowest load factor of the plant occurred during the day and as this period was several hours longer in the summer than in winter, the monthly load factors showed low during summer, and largely because of this the fuel consumption per kilowatt-hour was higher for the summer months than for the winter.

Costs

THE summary of operating economy is as follows: Gas per kilowatt-hour at the switchboard, 28.85 cu. ft. Load factor based on engines fully loaded when operating, 43.2 per cent. Over all thermal efficiency from gas meter to switchboard, 12.45 per cent. Over all thermal efficiency from gas meter to engine brake horsepower, 14.92 per cent. City water per kilowatt hour at switchboard, 0.653 cu. ft. Engine oil per kilowatt-hour at switchboard, 0.00463 gal.; valve and dynamo oil per kilowatt-hour at switchboard, 0.046 gal.; over all thermal efficiency from gas meter to switchboard, best month, 14.68 per cent; over all thermal efficiency from gas meter to engine brake horsepower, best month, 17.55 per cent. The over all thermal efficiencies are based on 950 B.t.u. per cu. ft. of gas, and the generator and belt efficiencies were reckoned as 88 and 95 per cent respectively and a kilowatt-hour as being equal to 3412 B.t.u.—The Armour Engineer.

NATIONAL ROADWAYS are being advocated by the National Highways Association, the completed system to include main highways through the northern, middle and southern sections from Atlantic to Pacific coasts, and north and south lines along each coast and the Mississippi valley. Trunk highways are planned to form intermediate routes and cross sections along the main lines of travel and link highways along diagonals to complete the network and feed into the trunks. The completion of the system is expected only after years of development, the idea being to work gradually toward a complete system, making use, so far as possible, of satisfactory roads already in existence and joining these by others. When finished, the plan will embrace 50,000 miles of road under federal control and maintenance similar to the French national system, and supplemented by feeders built by states, counties and townships. The plan is in charge of Charles H. Davis, president, and F. R. Hutton, secretary, National Highways Association, Washington, D. C.

COMBUSTION POWER*

Needs in Future Development of Big and Little Combustion Engines

REFERRING to what he had done and what he had dreamed of doing, Mr. E. T. Adams, formerly of Allis-Chalmers Co. and of Wisconsin Engine Co. and now with Rumely Products Co., told of what he believed the proper design for a really big gas engine. Five thousand kilowatts in a 2-cylinder horizontal engine with high piston speed and few parts should cost not over $25 a kilowatt with generator, those of the size at Gary costing now some $35. Mr. Adams doubted, however, whether such an engine would ever be built as the big blast furnace plants have been equipped, and conditions in big central stations are not favorable to the big gas engine. One difficulty met is the rapid throwing on of load with an unexpected change in the weather, as when 48,000 kw. is added in 8 min. at 10 o'clock in the morning on the New York plants due to a sudden shower. This is a condition where gas engine driven units could not be paralleled fast enough to meet the demand.

Another difficulty in very large cylinders, especially if there is hydrogen in the gas, is that the heat cannot be carried away fast enough, the cylinder gets hot, and actually starts to grow, increasing its length appreciably and permanently on the inside. The large engine also gives less power per cubic inch of cylinder volume than the smaller one, hence the investment increases faster than it should with increase of size.

Producers using crude oil have seemed a promising field and have been brought far towards success, but the recent rise in the price of crude, decreases the possibility of big power from this source, and drives us back on bituminous coal as the only producer fuel and the bituminous coal producer is not yet commercially ready in large sizes such as 5000 hp. Mr. Adams believes that the problem may be solved by the use of finely pulverized fuel.

Turning to the small engine using liquid fuel, Mr. Adams stated that the really big power in the aggregate is that used on the farm in small units; one Chicago mail order house sold in one year 50,000 hp. in engines averaging 2 hp., which gives some idea of the power used and the rapidity with which animal power is being replaced by mechanical. There is good engineering in this, for the farm load is a series of intense peaks with deep hollows intervening, and with animal power, the fuel cost goes on at just the same rate regardless of load conditions. With the combination engine, the fuel cost stops with load, labor can be turned to other uses, and the land required for raising food for draft animal is released for other uses.

At present gasoline is the great fuel for such work, but the tendency is more and more towards oil, and this drift will be rapidly increased with the rapid rise in price of gasoline which is sure to come in the near future.

One peculiar condition in the combustion engine field is the uniformity of heat efficiency regardless of size of engine or fuel. This runs at 8000 to 9000 B.t.u. per hp.-hr. for furnace or producer gas engines, for Diesel oil engines or for gasoline or kerosene engines, taking the best conditions for each. That is about 15 brake hp.-hrs. per gallon of gasoline or kerosene, though the automobile engine gives an average of only 5 brake hp.-hrs. for the same fuel. It would seem that a better performance will be secured by somebody before long for both stationary and automobile engines.

Commenting on the producer situation Prof. C. R. Richards of the University of Illinois stated that Professor Parr has succeeded in driving off the heavy hydrocarbons from bituminous coals at a low temperature, 750 to 900 deg. F., leaving a semi-coke which is a good fuel for producers and for domestic use. This is not yet in commercial form, but the laboratory experiments promise well. So far as the small engine is concerned, he believes that alcohol will come to be of importance, and that we shall eventually estimate the fuel value of an acre of land to raise crops for conversion into denatured alcohol.

J. C. Miller expressed his belief that electrical transmission of power from producer plants located at the mines will be one of our great future developments, a plan which is now being tried out at Durant, Okla.

Pulverized fuel was endorsed by Nisbet Latta as the key to success in the large bituminous producer. The limit of power has been the stoking, as 7 to 8 lb. per sq. ft. of cylinder surface has been the maximum to keep a free fuel bed, and this has limited to 500 hp. capacity in practice. There are now 3000 hp. of producers in operation in Paris on pulverized fuel and with satisfactory results. Great difficulty has been experienced in gas from bituminous coal, not from the tar, which can be taken out in the scrubber, but from the lighter liquids which form a kind of tar fog in the cylinder and cause the piston to seize in the cylinder. A dry gas is needed, free from all liquid constituents. In all cases, the producer must be designed to fit the coal, if satisfactory running is to be secured.

Replying to questions as to the use of water with the fuel in the crude oil engine, Mr. Adams stated that no water is used to about half load, and above that, the amount of water is graduated by the governor in proportion to the load which keeps down the cylinder temperature and improves the efficiency.

*From a discussion before the A. S. M. E. Meeting in Chicago.

THE TELEGRAPHIC REPORT from Boston informing the world that after extended experiments at the Jefferson Physical Laboratory of the Harvard University, Cambridge, Prof. Percy W. Bridgman had succeeded in producing "hot ice," is confirmed by a paper constituting the Proceedings of the American Academy of Arts and Sciences, Boston.

This phenomenon was produced by heating water to a temperature of 173 deg. F., and applying hydraulic pressure of 300,000 lb. to the square inch. To withstand such a high pressure, it was necessary to use a receptacle of nickel steel, which was 1½ in. inside and 4½ in. outside. As far as is known this is the greatest pressure under which liquid has been placed, the highest pressure obtained in earlier experiments being 50,000 lb. to the square inch.

While Prof. Bridgman's discoveries and deductions are of considerable interest to the scientist and offer to the layman a reliable basis for conjecture, which may or may not serve an end of practical value, it is obviously true that the ice and refrigerating industry is not affected. —Ice.

CORRESPONDENCE OF AN OLD ENGINEER AND HIS SON

Qualifying for Advancement; Appropriate Clothing; Adjustments

MY DEAR SON:

We were both glad to know that you arrived at the job all safe, especially mother. You know mothers have a feeling for the children that no father ever had, and they always seem to judge things from the view point of a generation ago. It is hard for a mother to become accustomed to the transition of events. You are her baby now just the same as you were 25 years ago and she still thinks that you need watching to see that you don't get hurt, the same as you did then.

Well, we were glad to see that you have grown into such a man. I did not think that when I last saw you several years ago, that you would ever get over those "kid" ways, but it seems that you have grasped the fact that life is a mighty serious proposition after all and that a man has to get onto the job and deliver the goods right straight along in order to be very much these days.

There are too many men hiding away from the boss that seem to have the mistaken idea that the world owes them a living and that it is coming to them whether they hustle for it or not. So it is but natural that they do just enough to keep from getting fired.

Yes, this world does owe each one of us a living, but let me tell you son, that by gravy, we have all of us got to get out and collect it. The custom is altogether too common for men, yes, and women too, for that matter, to do just about so much, and feel that if they do any more that they will not get any thanks for it anyway.

True it is that the boss cannot always see all the good things that a man does, but it does not take long for the average man in authority to get onto the fact that a man is not helping the cause along by being an incumbrance on the payroll.

It makes no difference whether a man is working out an intricate problem in railroad construction, a bridge, or a complicated reverse curve on a 3 per cent grade, or whether he is out digging post holes. If he puts his whole soul into his work, as if he liked it, it is soon noticed by those higher up. Some day there will be a position that requires a man of a certain caliber. Almost instantly his mind will pick out several men who have impressed him because they seemed to work because they liked it, and not because they had to in order to keep from starving to death.

Then it is simply a matter of picking out the man that is better fitted for the position, often simmering down to the one that smiles in preference to the one who does not because he wasn't born that way.

Many men will never know how many times they have been eliminated from an advancement contest because of their faults. You perhaps remember Jimmie Driscol who worked at Blair's foundry when you were a boy. Jim was sober, industrious, and liked the work and could get it out in time. But Jim was never known to get to work any more than a second early. Usually he was just going through the gate or else running down the street just as the 7 o'clock bell rang. And Jim is still doing that same thing and wondering why his other good qualities never landed him a better job.

You have often heard the statement made by employes, "What's the use of breaking our necks getting the work out? We do not get any more thanks for it anyway." A man's pride in giving an honest day's work for an honest day's pay, ought at least to inspire him to give the boss a square deal.

Well, Donny, I have sort of written you a sermon before I thought of it but I guess that it will not do you any harm. So the "gang" was glad to see you back again? Well, that is the test of manhood. When the boys that one associates with give a man a cordial welcome when he returns after an absence, that is a sure sign that he is looked up to by them as a man. And after all, is there any more cordial welcome than the grip of an honest fist well covered with dirt from honest labor?

You say that you are beginning to feel that the farther you get from the overalls the more sham there seems to be. Well, this is true in a sense, although there are many businesses and professions where overalls are as much out of place as a woman engineer. Still I believe that there is a great deal of truth in what you say, just the same. A boiled shirt and a ten-cent tie will make a snob of some men, or rather boys, whereas, if they had had to put on overalls and stay or rather start in a position for which they were fitted, they would not have had the chance to find out how important they were.

Still, there are men who wear overalls that are more or less of a sham too. Lots of men put on overalls so as to make it appear that they are all ready to jump right in and cut off a big slice, yet when Saturday night comes they have hardly soiled them.

This doesn't mean that a man must get himself all over cylinder oil and coal dust just because he has a suit of overalls on. You often see men in positions of trust and responsibility who would no more think of wearing overalls than they would of wearing a plug hat around the plant. No matter what the job is, no matter whether the helper can get away with it or not, they seem to take special delight in getting their clothes dirty just to show their contempt for dirt and their ability to buy another suit when that one is spoiled.

But to get back to the overalls again. Did you ever see a man who wore overalls at work who was ashamed of them? Very few. When a man gets all togged out in a suit of jeans, there is a certain spirit of independence about him, for he feels that he does not have to be thinking about his good clothes all the time like a woman crossing a muddy street.

Well, Donny, we are glad to see that you have been promoted again or rather assigned to a different task, for there are some very good reasons why a job on the repair gang is one not to be despised, yet, there are so many, many things to be learned in the engine room that one cannot begin too early if he has any aptitude for the business.

Now that you are safely settled in the engine room for the time being, let me tell you one thing: lose the monkey wrench. This does not mean to drop it down between the boiler setting and the wall, or hide it in the hotwell, but whatever you do, Donny, don't start to twist and screw every rod, nut or connection on the engines in an endeavor to experiment and learn.

The firm paid out good money for those engines, generators etc., and the chief is paid good money to

see that they earn a good interest on the money invested in them. When the engine stops, everything stops, so when they are running all right, let good enough alone.

There is nothing that can raise more cain around an engine room than an engineer (?) who is always screwing in or out on every rod and connection on the valve gear, and shifting the eccentrics a little for good measure. There never was a community that boasted of a Corliss engine, but what had a good, live specimen of the "monkey wrench engineer."

How often you hear a man say, "She hasn't bin runnin' just to suit me f'r some time, so I slacked up a little on the eccentric rod and took up a mite on the 'saust rods, but it don't seem to he'p 'er a bit, f'r she rattles just the same."

Deliver me from the man that is everlastingly tinkering with the machine. If you have to make adjustments, or you find that something is not right, look into the matter in a scientific manner and if it is a matter that has to do with the valve gear, put on the indicator.

The indicator will tell you more about an engine in 10 min. than you can learn with a monkey wrench and a hammer in 10 weeks, and when you get done it will give an answer that you can bet your last kopeck on.

Don't worry yourself to death or lie awake nights because there is a noise in the crosshead that defies detection. This doesn't mean to let her run any old way. But whatever you do, go at it as a business and make a businesslike job of it, and if you do this every time you have to put a wrench on the engine, it will last a great deal longer—and so will you.

Well, my son, it is time to close and put the cat out and go to bed. Mother sends her love, and wants you to remember her to Hazel. Of course they never met, but it looks as if they would some day.

Affectionately, your father,
Sandy MacDougal.

REPAIRING A PIPE

Difficulties Encountered With Underwater Pipe Line

By H. L. Sherman

EARLY last summer we noticed a decided increase in the amount of water pumped. Each week we had to run the pump more strokes to keep the reservoir full. As this might come from inefficiency of the pump, the water valves were examined as well as every point about the pump that could cause this.

No trouble being found then, we made an examination of the sewer manholes and mouths in an endeavor to trace the waste, but could find only the usual amount of water coming through and from these sewers. Inquiries were instituted and inspections made as far as time permitted in an endeavor to stop the leaks. Thus, by a process of elimination, we decided that there probably was a leak in the line crossing under the river.

We concluded therefore to make the following test: We dug down to the line in the street, at the gate that shuts the water off from the river line, and tapped the line ½ in. (this should have been 1 in.), without shutting the water off on both sides of the gate. We next put in a bypass containing a water meter between the taps, or in other words, around the gate.

Then by shutting the gate on each side of the river for 5 min. all the water going out the leak passed through the meter. This was 15 gal. a minute. As we were very busy at that time and the leak did not seem to be of an alarming size it was not repaired at that time. The water and connection was left on. There was a box put around it and the bricks replaced in the street.

The amount of water pumped continued to grow. Our recording gage in the office showed lower and lower pressure each night when the legitimate consumption was off. The registered pressure went down from 155 to 147 lb. a square inch.

One night at 11 o'clock we shut the gate on the farther side of the river. Then at 11:20 we shut the gate that fed the line. The chart next morning showed an increase of 7 lb. a square inch when the second gate was closed. That is, the leak was cutting down the pressure 7 lb. The next day the meter showed the leak to be 25 gal. a minute, which was our meter capacity and likely less than the true amount.

The next step was finding the leak. One-inch taps were made on each side of the river near the water's edge. A compressed air line was run from a nearby machine shop. The line was drained to the water's edge, the gates on both sides of the river being closed.

The air line was then connected and the balance of the water blown out. The tap on the farther side of the river was then closed. Soon the pressure of air ran up, showing a violent disturbance on the surface of the water about 80 ft. from the farther shore. The pipe line was laid in a trench about 4 or 5 ft. deeper than the river bottom.

The last time we had investigated the line was still uncovered. A diver was hired to make the investigation. An 8-in. split light Dressor sleeve was ordered by telegraph to be sent by express, also one by freight for future needs. The diver arrived next morning, bringing with him his helper while his outfit came by express. A skiff and a calking boat had been secured for the diver to work from.

A hoist boat was at last secured for use the next day. This boat was lying about 6 miles below and had to have some flews put in the boiler before it could be used. We next secured the services of a large motor boat to tow the hoist boat up. The next morning there was a heavy fog on the river. We started for the hoist boat slowly, keeping in sight of the river bank. Three hours were consumed going 6 miles. At last we reached the hoist only to find that the boilermaker had forgotten his flue expanders. This caused another delay but about noon the hoist boat was in place, and at 1:30 was digging. At 4:30 digging was completed and the line uncovered. The diver made one dive, coming up in about 3 min. He said it was ready for the sleeve but he would not finish until next day as he did not propose to work overtime. The hoist was sent back. The next day the water was shut off and the diver put on the sleeve. An air test showed another leak. A flat plate of steel bolted by stirrup over a piece of soft rubber repaired this one. Probably this leak was caused by being struck by the orange-peel digger. Another test showed the line to be tight.

The expense of this job was nearly $200. Some of the items were diver's bill $81.50; hoist boat $25.00, motor boat $8.00, sleeve about $12.00.

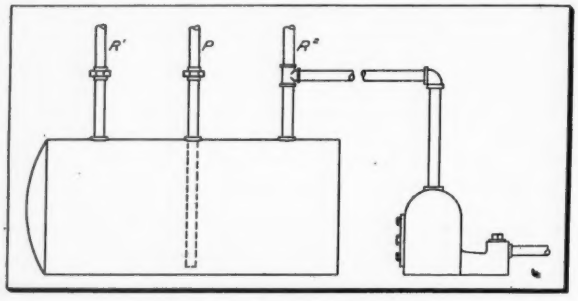
The first full month showed about 5,000,000 gal. less pumped, besides a decided improvement in the service on the hill tops.

LETTERS DIRECT FROM THE PLANT

Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

TRAP WISDOM

NOTICING Mr. Simpson's article under the above title in the Feb. 1 issue, and the sketch illustrating it, I cannot help adding the question mark. If his sketch shows the complete piping of the receiver it is no wonder that the return clogged up on turning on



PROPER PIPING FOR RECEIVER

a new or cold coil, as the tank was practically useless to take care of any fluctuations in the amount of water coming into it. It is presumed, however, that the pipe P extended as shown by the dotted lines in the sketch herewith. W. T. Meinzer.

LAP ON CORLISS VALVE; STOPPING A CONDENSING ENGINE

IN the February 1 issue, Mr. Dixon explains what lap in a Corliss engine is, but he neglects to say what it is there for. Now suppose the engine had a heavy load thrown on it, it would not cut off, in other words it would be carrying the hooks, if we did not have any lap on the valve, steam would blow through. So the lap is for the purpose of cutting off the steam before the engine reaches the end of the stroke, in case the governor does not cut it off.

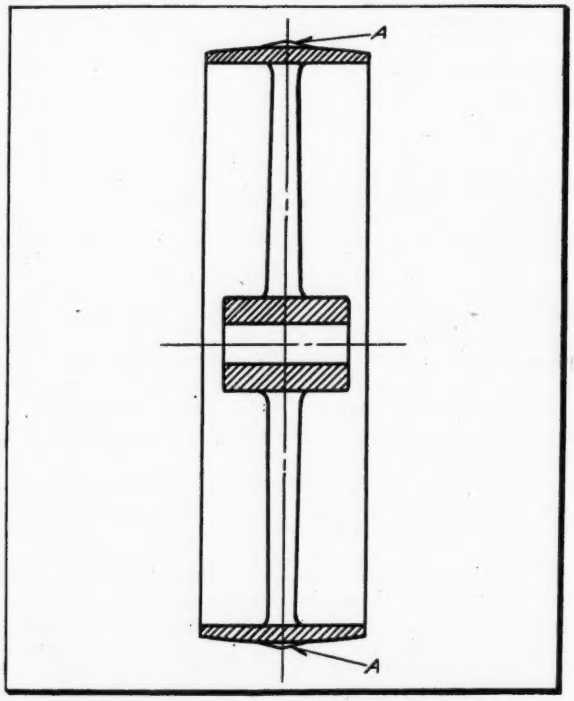
If, while shutting down a compound condensing engine, the condenser pump should stop, what would you do? I do not agree with Mr. Dixon's answer to this question. In my opinion if you close your throttle valve you create a vacuum in the low-pressure cylinder. If your pump stops, vacuum breaker failing to work, your condenser will be flooded. If you have a greater vacuum in the low-pressure cylinder than you have in the condenser, when your exhaust opened for release, water would rush in, the piston would push it out until compression takes place, trapping the remaining water, and damage would be sure to follow.

To stop a condensing engine which exhausts into a jet condenser, I would close the throttle valve, and wait until the engine, almost came to a stop. Then I would unhook the valve gear, give it steam on the end which required it, to bring it to a stop, often you don't need to admit steam. Now after closing the throttle valve, if I found that the condensing pump had stopped and condenser was flooded with water, I would open slightly the throttle valve, and that would keep the engine turning over. Then I would close the valve between the low-pressure cylinder and the condenser, which would open the atmospheric valve, running the engine on high pressure, then I could stop it in the usual manner.

While the engine is running condensing, of course the valve between the low-pressure cylinder and the condenser is open. If it wasn't, you would have to run high pressure. Tobey J. White.

REMEDY FOR BELT TROUBLE

IN the July 15, 1912, issue of Practical Engineer, I asked for a remedy for our trouble with the belt that drives the countershaft of our air compressor. This belt has defied us a long time and readers may be interested to know how we remedied the trouble as described.



PULLEY CROWNED WITH STRIP OF LEATHER

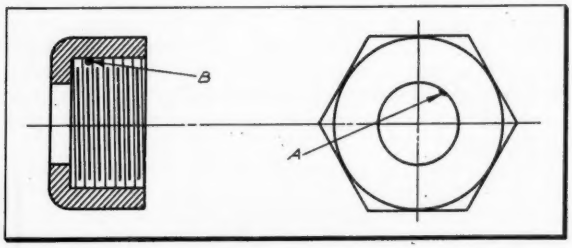
We took a piece of single belt 2 in. wide and long enough to reach around the driven pulley and scraped it about as shown in the sketch at A A, and soaked it in hot water so as to enable us to take most of the

stretch out of it, after which we riveted it to the pulley face as shown at A A. Copper rivets were used, and now the belt runs all right. We find that even a thin narrow string of belt lacing tightly wound around the center of the pulley face will help to keep a badly acting belt on a pulley, providing the belt does not slip.

T. C. R.

CLEANING GAGE GLASSES

REPLYING to the letter by E. C. B., page 144, Jan. 15 issue of Practical Engineer, there are several causes, either or all of which may have operated to break his gage glasses. I never have any trouble from using a wire in cleaning gage glasses. The only gage glass or glass tube in which I would not insert a wire to clean it, is that over the nozzle or needle valve of a lubricator. A slight scratch on the surface of this nozzle where the drop of oil accumulates in the sight-feed glass of the ordinary or double connection hydrostatic lubricator may cause the drop of oil gradually to crawl over on one side of the nozzle and presently crawl up the side of the gage or sight-feed glass tube. This nozzle, too, is easily scratched; but this is getting away from the issue.



LOCATION OF PARTICLES THAT MAY CAUSE BROKEN GAGE GLASSES

E. C. B. should have submitted a sketch of the fittings which connect the gage glass with his Leblanc condenser, because many of us, and those, too, most likely to be interested in his problem are not familiar with the details of his condenser, the Leblanc. If he had to take the gage glass out of its fittings to clean it and then did not clean the old packing out of the packing nuts and used new packing when replacing the glass in its fittings, the old packing being rather hard and set, may crack the glass and the operator not notice it at the time. Also the packing nuts must be cleaned thoroughly; a slight lump as at A in the sketch may be the cause of breaking a glass. Also lumps on either side of threaded portion of the packing nut, as at B, will cause the packing on one side to pack tighter than on the opposite side of the glass and is sure to break the tube, all of which the operator may not notice, and when the glass is cut into service it will give way of course.

In taking the gage glass out of the fittings to clean it, or in removing a plug from the upper fitting of the gage glass in order to swab out or clean the glass, the fitting under the stresses of the wrench may have been thrown slightly out of line with the fitting on the opposite end of the glass, which would probably crack the glass and it would give way when cut into service.

Several months ago one of the gage glasses on one of our boilers let go, and I did not have anything but an old gage glass that I could replace the broken one with, and it was so dirty and gummed up that it had to be cleaned if I were to use it. I used coal oil, gasoline, crude oil and what not trying to clean that glass, but none of these things would clean it, so I filled the glass about half full of ordinary sand and then poured in some coal oil to help the sand and after shaking this mixture around for a while I had a clean glass. I placed the glass in the fittings on the boiler where we carry 140 lb. gage, and the glass is still in use.

T. C. R.

INDICATOR DIAGRAMS

ON page 236 of the Feb. 15 issue are reproduced some cards for discussion. In my opinion the load is more evenly divided when cards No. 3 and 4 were taken than shown by No. 1 and 2; all cards, however, show the engine will stand a little more compression on the crank end. The humps are more apparent in cards No. 1, 2 and 3 than in No. 4, the steam line on the head end is best on No. 4. I should suspect the indicator is at fault and should suggest that it be looked over carefully to see that there are no loose or binding connections, then thoroughly cleaned and oiled before making further changes in valve setting.

John M. Leitch.

THE OHIO LICENSE LAW

I READ with pleasure the requirements of the Massachusetts Engineer's License Law and while I am not thinking of making an application myself in that state it might be of interest to some outside of Ohio to know our law here in regard to engineer's license.

First, one is required to have spent 1 yr. as an oiler, fireman or helper in an engine room and be 21 yr. of age. He then presents himself before the examiner of his district (we have 8, I think, in this state), who will require a sworn statement by the applicant and a fee of $2 which is not returned if the applicant should fail. He is then given a list of 50 questions and must answer at least 60 per cent of them before he is granted a 3rd class license and if he fails he may have another examination 90 days later. The examination consists of a written explanation of the questions contained on the examination cards such as setting the valves of different engines with automatic and throttling governors, their different workings, the horsepower of several sizes of engines; duplex pump valve setting and their principle of working; the different engine room devices and what used for; the different designs of horizontal return tubular boilers as well as water tube and their fixtures and travel of the gases, what heating surfaces they contain, the size being given, and how they ought to be connected where a number of boilers are being used. There are also some questions on firing and how boilers ought to be handled as well as laying up a plant for some time and also taking charge of strange plants. In fact all questions are practical and the idea of the examination is to find out how well posted the applicant is and if he is capable of handling a large plant. We have 1st, 2nd and 3rd class licenses; an applicant must have 2 yr. experience for a 2nd class and 3 yr. for 1st class papers. None of our licenses are limited as we have some chiefs in quite large plants that hold only 3rd class papers who are the very best engineers; at least they have been in charge of their respective plants for years.

I think we have a fair examination for all; of course we have some who claim not, but any one who will try ought to be able to pass the 3rd class grade. Our license

runs for 1 yr. (if not sooner revoked for cause) when we are notified by our district examiner, then we send our old license in with $2 for renewal and he mails the new license to us. We also have a chief examiner who has charge of the work of the district examiners and also who is at the head of our boiler inspection law, which went into effect Jan. 1, 1912. Roy Stahl.

METALLIC PACKING FOR PUMPS

I HAVE read with considerable interest Mr. Robinson's letter in the February 1 issue of Practical Engineer, page 188. His experience with rod packings is of value, and I thank him for responding to my request in a former issue. What I had in mind particularly was the use of metallic packings for the water ends of pump rods.

I have had experience with various kinds of packing, both metallic and fibrous, in the boxes of piston rods and valve stems, but I have not seen any application of metallic packings to the water ends of ordinary pumps. I presume that metallic packing is used for pump rods somewhere, or if it is not, why not? What I would like to learn is, have any readers of Practical Engineer known of metallic packing being used for that purpose, and with what results as compared with the use of flax or other soft packing.

It seems to me that metallic packing would be better for pump rods than any soft packing when all things are considered, yet we hear little or nothing about that matter. Many a pump rod is packed with soft packing which is screwed up so tightly, that the frictional resistance must be enormous, comparatively speaking. This screwing up tightly could not occur with most metallic packings that could be applied, without the fact being discovered soon.

When frictional resistance and possible scored rods are thought of, it seems as though metallic packing for pump rods would make a worthy competitor for flax or other soft packings.

Has any reader anything further to offer on the subject? Charles J. Mason.

PLANT MANAGEMENT

BY reason of my accepting a position in a central station in one of the eastern states, a short time ago, it was my good fortune to see how a really up to date plant was managed economically and satisfactorily to every one connected in any way with it. The crew consists of 3 engineers, an oiler, and 2 firemen. Owing to the chief, who has the best method of handling men that I have ever seen, the crew works in perfect accord, each one ready to do his share of the work and part of another's if need be. There is a strong fraternal feeling between them from chief down to firemen and to this is due, in my belief, the well organized operation of the plant.

The chief's hours are from 7 a. m. to 4 p. m. That of the 2nd engineer from 1 p. m. to 10 p. m., and the 3d engineer, 10 p. m. to 7 a. m. The firemen have 12-hr. shifts, changing at 1 p. m. and 1 a. m. The engineers' wages are $90, $70, $60 a month respectively, the oiler and firemen receiving $50 a month. My stay was of necessity of short duration and in this way I missed getting the data and figures showing the relation between the output and the cost of production.

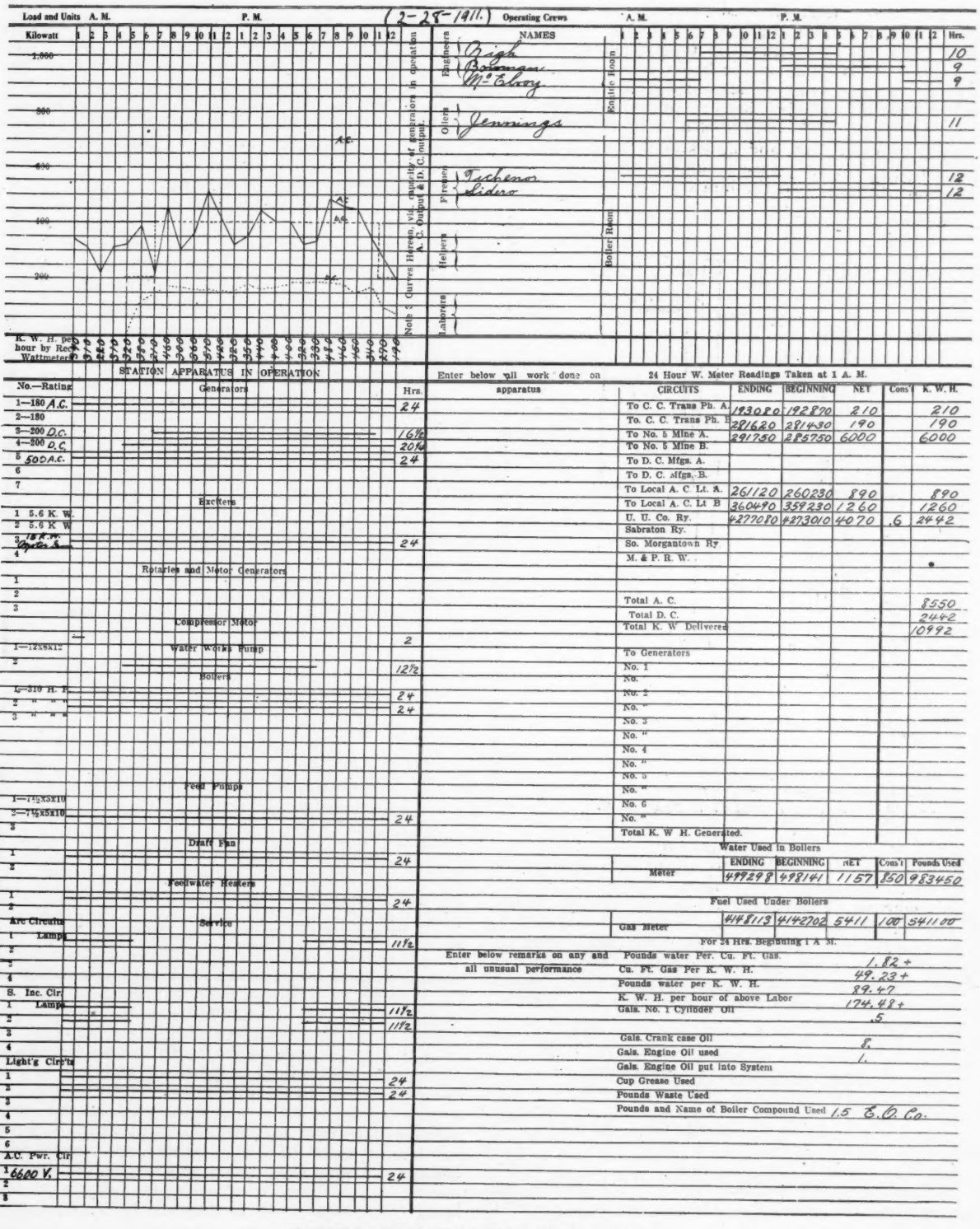
A report is made each day, giving the amount of fuel and water used, and just the amount of power produced and in what way it was used and by whom. The plant consists of the following apparatus: Boiler room, 3 310-hp. Stirling water-tube boilers, each equipped with 16 Kirkwood gas burners, 8 on each side of furnace, burning natural gas, and a Chaplin-Fulton gas regulator supplies gas to the furnaces in the amount needed; 2 Platt Iron Works outside center-packed plunger feed pumps, 9 by 6 by 10 in.; 1 Snow duplex water works pump, 12 by 6 by 12 in.; 1 Blake, duplex oil pump, 3 by 2 by 3 in.; 1 1000-hp. Pittsburgh open feed-water heater which raises the feed-water temperature to 210 deg. The boilers are furnished with Reliance water columns, and 2 pop safety valves of ample capacity are on each boiler. Feed-water regulators are to be installed soon.

The engine room contains 2 200-kw. Westinghouse automatic compound single-acting engines direct connected to Westinghouse multipolar d. c. generators which furnish power to the street railway at a voltage of 550, speed 200 r.p.m., cylinder size, 18 by 30 by 16 in.; 2 Westinghouse automatic compound single-acting engines, 16 by 27 by 16 in., speed 240 r.p.m. belted to Westinghouse 180-kw. 2-phase a. c. generators, making 515 r.p.m., and generating current at 2200 volts which is stepped up by transformers to 6600 volts for the commercial line, which is 3 phase. The lighting circuit is supplied at a voltage of 2200; 1 Westinghouse motor-generator set of 180 kw. capacity; 1 500-kw. mixed-pressure turbine working in connection with a Lablanc condenser, and 1 12 by 12 in. slide valve engine direct connected to a fan 10 ft. in diameter, located in the uptake to the stack, making a very efficient induced draft system; a 15-panel switchboard is furnished with the usual fittings for handling the various circuits easily and quickly. The pipe lines and Holly system are laid out in a manner to accomplish the best results in the least complicated way. Everything is kept in the pink of condition and cleanliness, although at times the engines carry a heavy over load for hours at a stretch, which of course makes it quite an item to keep them in good order and economical adjustment. This station could in several ways serve as a model to those contemplating building a plant, and to many chief engineers who have trouble in managing their subordinates.

I have secured a copy of the daily station log for the date given, which gives all necessary data on the operation except the cost of fuel and water which is under the control of the power company, this of course, makes a considerable saving in these bills. The water evaporation looks high but a goodly percentage of it was used for the glands and water seal on the turbine and condenser pump and make-up water for the air pump. The evaporation used to run about 1.1 lb. water to 1 cu. ft. gas; that is, before the turbine was installed. The way the turbine (6600 volts 3-phase) is run in parallel with the 2200 volt 2-phase generators is as follows: The 2 150-kw. transformers are wired to take 2200 volts 2-phase current and produce 6600 volts 3-phase current, and the turbine is connected behind the transformer on the 6600 volt, 3-phase side and runs in parallel with the 2200 volt generator through the transformer. The transformer acting as a step-up or step-down transformer, according to which side is the heavier in proportion to the generators running.

The chief's method in handling his subordinates to secure the fraternal spirit mentioned can be explained in just 11 words: "Do unto others as you would have others do unto you." Each member of the crew tries to live up to this rule and as a result their work is never slighted in the least, and they are always ready to do a "good turn" when chance offers. This chief

never "goes up in the air" when a mistake is made or an accident happens, and gives everyone in sight a "calling" whether to blame or not, like a good many "boss," but is "hail fellow well met" with every one in the plant and treats all alike no matter what their position. No one with such examples before him could



DAILY LOG SHEET OF A WELL MANAGED PLANT

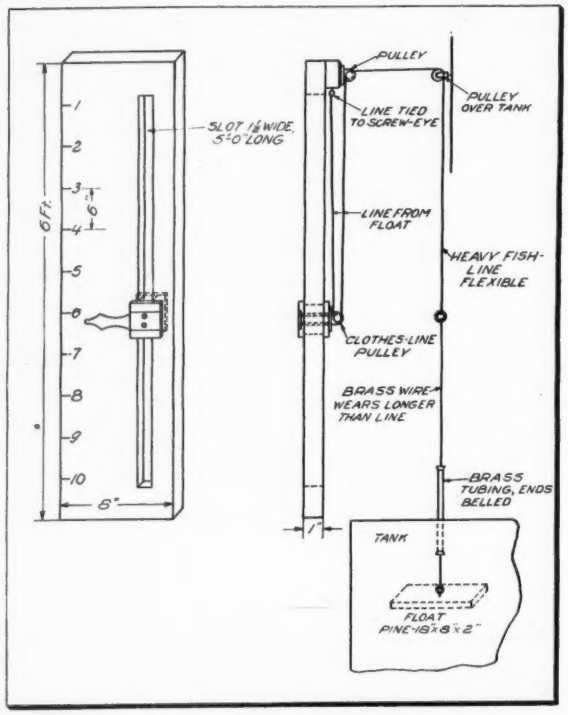
engineers do who are continually complaining of the kind of help they have. He doesn't consider it necessary to "stand on his dignity" to show that he is do less than his best, and in this way they all work to a common end, namely, to please "the big boss," not

Le Roy Scott.

SUCCESSFUL TANK GAGE

AFTER trying 3 different ideas for a suitable and reliable gage to register the depth of the water in our supply tank situated underground and at a short distance from the power building, I made a gage after my own ideas which works perfectly.

The gage is hung on the boiler room wall and is easily seen and read. The tank is 10 ft. deep, but on account of insufficient head room in the boiler room the gage board could only be 6 ft. long (a 5-ft. board makes a neater size, and appearance also, than one 10 ft. long), so I had to use a suitable reducing motion to reduce the travel of the index.



GAGE TO INDICATE WATER LEVEL

After trying 2 different motions, which gave more or less trouble, I decided to use pulleys arranged as shown in the sketch which works without any trouble or attention. The figures are spaced 6 in. apart and read feet of water. The float may be made of 2-in. pine planed and shellaced so as not to water-log, but must be heavy enough to handle the cord and index. The weight on the index should be only heavy enough to keep the line taut and insure the index lowering when the float rises. J. A. L.

CLEANING GAGE GLASSES

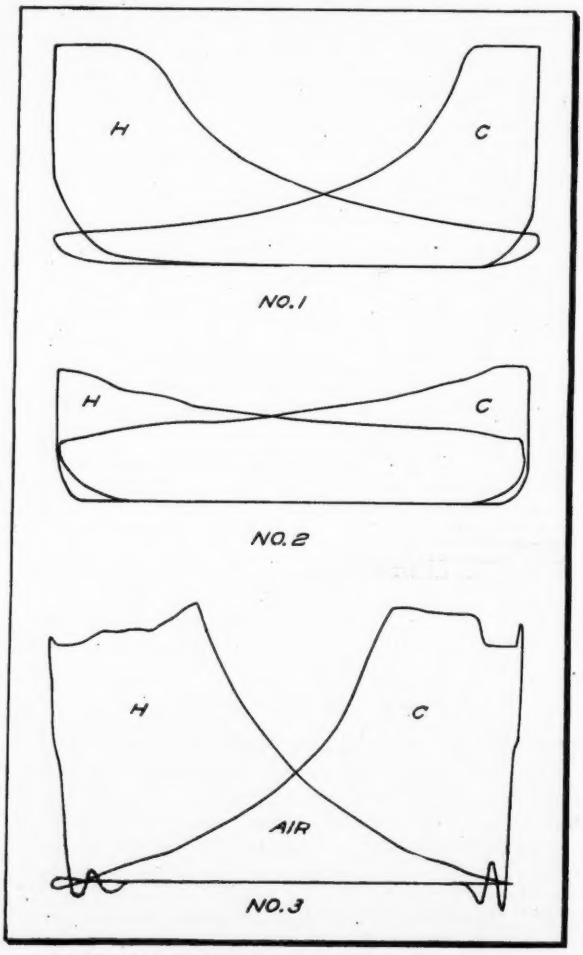
WHILE I am not in a position to state definitely what caused the glasses to break, I can tell E. C. B. how to clean gage glasses effectively without removing them from the gage cocks.

First get some muriatic acid in a shallow vessel, next heat the glass by blowing water and steam through it, then turn off the gage cocks tightly and with the drain cock open immerge the cock into the acid so that when the glass cools the vacuum which forms will draw the acid into the glass and cut off any and all dirt. A. D. Trussler.

AIR COMPRESSOR CARDS FOR CRITICISM

ACCOMPANYING indicator cards were taken from 14 by 22 by 36-in. Allis-Chalmers air compressor; No. 1 from steam cylinder running at 88 r.p.m. on 125 lb. steam and 29 lb. air pressure with a 60-lb. spring, engine being controlled by the governor. No. 2 was taken at 59 r.p.m., 124 lb. steam, 29 lb. air pressure, using 60-lb. spring, the engine being throttled. No. 3 is from the air cylinder, speed 88 r.p.m., 30 lb. air, 125 lb. steam, with 16-lb. spring.

Steam end of the compressor is equipped with Corliss valves, air inlet valves are also of Corliss type, outlet valves are spring poppet.



CARDS FROM STEAM AND AIR CYLINDERS OF AIR COMPRESSOR

Any criticism would be appreciated, but I think all cards are good. Engine exhausts into a Cochrane heater and thence through heater coils. Condensation is returned to the heater and then to boiler-feed pump. There is a vacuum shown on air card which I believe is practiced on all efficient compressors of recent date, allowing air in cylinder to expand to and below atmospheric pressure before allowing the inlet valves to open. N. V. Tanner.

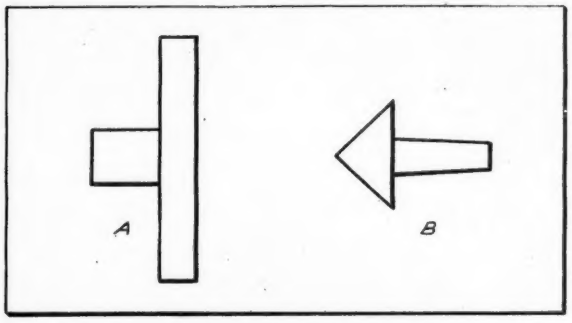
ALL LIFE IS A SCHOOL, a preparation, a purpose: nor can we pass current in a higher college, if we do not undergo the tedium of education in this lower one.

Successful Kinks From The Plant

For Saving Time, Work and Trouble

Kink for Lathe Workers

THIS sketch shows a way that may save time for some lathe work; A represents a face plate on lathe; B represents a center to be placed in tail stock of lathe. This center can be made any size desired. Any flat piece of casting having a small hole in center or not larger than center itself can be more quickly centered than by guess work. First, place casting against face plate or between 3 or 4-jawed chuck, then screw



CENTERING PIECE FOR LATHE

tail stock center into hole of casting; casting may then be bolted on or the jaws of a chuck screwed down on it; then the tail stock center may be withdrawn from the hole. Dan Schiffbauer.

Babbiting a Crosshead Shoe

THE babbit lining of one of the crosshead shoes of one of our vertical ammonia compressors came loose and cracked and a number of pieces dropped out, so it became necessary to put in a new lining.

As our lathe was not large enough to swing the shoe it became necessary to babbit it in place.

The piston rod was first centered between the guides by adjusting the shoes; the crosshead was brought up to nearly the top of the guides, the connecting rods disconnected, and the defective shoe taken out; the old babbit was chipped out and the shoe cleaned with gasoline and put back in place on the crosshead. The adjusting wedge was set so as to bring the shoe as close to the crosshead as possible and allow the maximum amount of metal to be poured between the shoe and guide.

The good shoe was then brought tightly against the guide by placing blocks of wood against the piston rod on the opposite side and using wedges to tighten them.

Pieces of 1-in. board about 3 in. wide and a little longer than the shoe were placed on each side of the shoe and wedged in place against the sides of the shoe and the guide. On the bottom end of the shoe a piece was cut to fit the curvature of the guide and blocked in place.

Holes in the guide and shoe were plugged with wooden plugs. The openings and joints were plastered with fire clay.

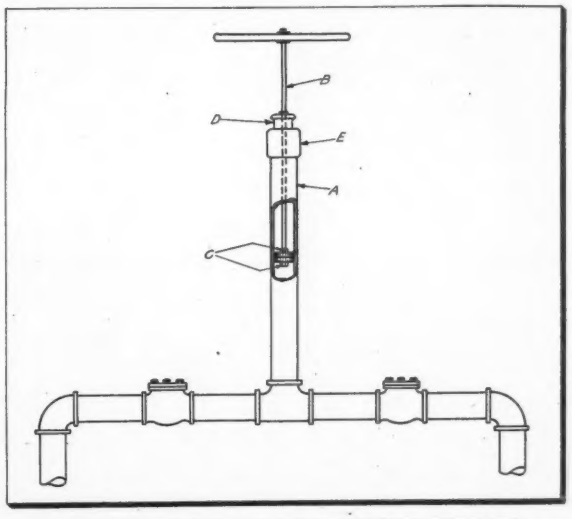
When everything was ready the metal was heated in a portable forge and poured until the metal came up even with the top of the shoe.

When it had cooled, the board strips and blocking, etc., were removed, the shoe taken out, scraped, and the edges trimmed and put back in place. The connecting rod was then connected, the shoe adjusted to an easy running fit and it has been running without trouble ever since. Thos. G. Thurston.

Home-made Hydraulic Pump

THE accompanying sketch shows an easily constructed hydraulic pump I made to test a new piston I had cast for our gas engine.

The cylinder A was made of a piece of 1¼-in. brass pipe 24 in. long, the ram B was made of a piece of ½-in. rod 24 in. long. Two washers are ½ in. thick and a leather washer is cut a little larger than



HYDRAULIC PUMP MADE FOR TESTING PURPOSE

the diameter of the pipe A. The nuts CC hold the washers together, the handle is a piece of 1-in. pipe with a ½-in. hole in the center and held to rod B with 2 nuts. The guide D is a 1¼ to ½-in. bushing screwed in the coupling E. A 1¼ by ¾ by ¾-in. tee, nipples 6¾ in. long, two ¾-in. check valves and 2 ¾-in. ells completed the job.

The piston was tested with 300 lb. pressure with ease. J. B. Linker.

TO LIVE IN THE PRESENCE of great truths and eternal laws—that is what keeps a man patient when the world ignores him—and calm and unspoiled when the world praises him.

—Balzac.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Answers to Massachusetts Examination Questions for First Class License*

ALTHOUGH the question does not state the character of the joint to be figured, the fact that 2 different pitches for the rivets are given indicates that the joint is of the butt strap construction as shown in Fig. 1.

We will assume it to be triple riveted. As the question does not ask for an analysis of the joint we will take the simplest manner of figuring to ascertain the percentage of strength of the joint in comparison to the strength of the solid plate.

The weakest place in a well designed joint of this type is along the first row of rivets, because they are in single shear, and as we figure the modes of failure as we approach the center of the joint where the plates are butted, the strength continually increases.

The percentage of strength of the sheet after drilling the rivet holes, to the strength of the solid plate

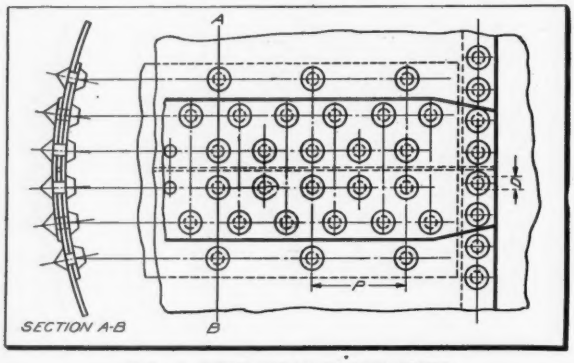


FIG. 1. BUTT STRAP BOILER JOINT

for the same length as the pitch of the rivets is found by subtracting the diameter of the rivet from the pitch P, Fig. 1, dividing the remainder by the pitch P, and multiplying the result by 100.

In our example we have $7 - 0.8125 \div 7 = 0.8839$ $0.8839 \times 100 = 88$ per cent.

As the rivet holes are drilled 1/16 in. larger than the rivets, and in good work the rivet should completely fill the hole, the diameter of the rivet is taken as equal to the diameter of the rivet holes. So, for a 13/16-in. rivet the diameter of the hole is 7/8 in. and the area after driving 0.6013 sq. in.

The question does not state the rivet material which is assumed to be steel, and as the rivets in the outer row are in single shear they will be assumed to have a shearing strength of 42,000 lb. per sq. in. To find the percentage of strength of the rivets to the plate in a distance equal to the greatest pitch of the rivets, we multiply the area of 1 rivet by its shearing strength and the number of rows of rivets considered in this case 1, and divide that product by the pitch of the rivets times the thickness of the plate and that multiplied by the tensile strength of the plate.

This area of the 7/8-in. driven rivet is 0.6013 sq. in., $\times 42{,}000 \times 1 = 25254.6$ lb. The pitch of rivets 7×0.8125 (the decimal of the plate thickness 11/32) $\times$ 60,000, the tensile strength $= 341{,}250$. Dividing 25,254.6 by $341{,}250 = 0.74$. This multiplied by 100 to reduce it to a percentage $= 74$ per cent.

This is a lesser value than the strength of the sheet as previously found, due to the fact that the diameter of the rivet specified in the example is larger than usually used for the thickness of the plate given. So in figuring the safe pressure we will use the factor 74 per cent as the efficiency of the joint.

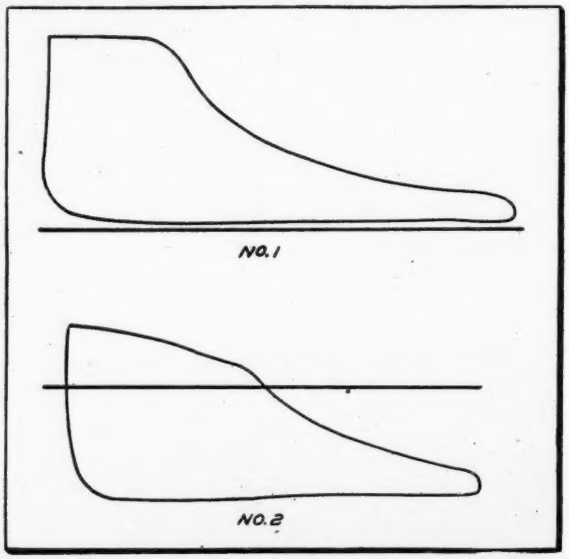


FIG. 2. TYPICAL INDICATOR DIAGRAM FROM CROSS-COMPOUND ENGINE

The formula for finding the safe working pressure is $T S \times t \times \% \div (R \times F.S.)$, in which T S represents the tensile strength of the plate taken as 60,000 lb., per sq. in., in our example. When the tensile strength of the plate is not given and the material is known to be iron, Massachusetts Rules take it as 45,000 lb., and 55,000 lb. for steel. If the material is not given the safest course is to assume it to be iron and figure accordingly. t represents the thickness of the plate and % the efficiency of the riveted joint. R equals the radius of the boiler, F.S. the factor of safety, which according to the Massachusetts Rules is to be taken as follows:

For boilers not over 10 yr. old, 5.
For boilers over 10 and not over 15 yr., 5.5.
For boilers over 15 and not over 20 yr., 5.75.
For boilers over 20 yr. old, 6.

Questions appeared on page 192, February 1st, issue.

And for boilers the longitudinal joints of which are riveted, the shells or drums of which are not exposed to the products of combustion, 5.

We will assume our boiler to be new and of the tubular type and will use 5 as the factor of safety. As practically all boilers are built of steel nowadays, the boiler is figured on that base. Diameter boiler 54 in.; the radius $= 54 \div 2 = 27$ in.

$$\frac{60{,}000 \times 0.3437 \times 0.74}{27 \times 5} = 152 \text{ lb. per square inch.}$$

2. As all the necessary details to proceed intelligently with the example are not given it is necessary to make certain assumptions. As the material and diameter of the braces are not given, we will take them to be of steel, weldless, and diameter of 1⅛ in. The steel heads will be assumed to be 9/16 in. thick.

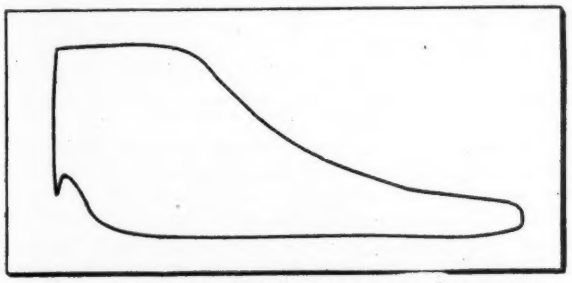


FIG. 3. DIAGRAM SHOWING LEAKY EXHAUST VALVE

Having the diameter of the boiler, also the height of the top row of tubes to the shell, it is necessary to find the area in square inches in the segment of the head to be braced. The formula for the area of a segment is,

$$\frac{4\,H^2}{3}\sqrt{\frac{2\,R}{H} - 0.608} = A, \text{ or } \frac{4\,H^2}{3}\sqrt{\frac{D}{H} - 0.608}$$

in which

H equals the height in inches from top row of tubes to shell, minus 5 in., because the head will support 3 in. all around and the tubes 2 in. above them.

R equals the radius of the boiler, minus 3 in.

D equals the diameter of the boiler after deducting 3 in. all around the head for the self-supporting surface that the flanging of the head will sustain safely.

0.608 equals the constant.

Height $24.5 - 5 = 19.5$. $19.5 \times 19.5 = 380$. $380 \times 4 = 1520$. $1520 \div 3 = 507$.

30. $30 - 3$ in. $= 27$ in. $27 \times 2 \div 19.5 - 0.608 = 2.161$.

$\sqrt{2.161} = 1.47$. $1.47 \times 507 = 745.29$ sq. in., which the 12 braces support, each brace holding $745 \div 12 = 62$ sq. in.

As 7500 lb. per square inch area is allowed for a crowfoot or diagonal brace, when made of steel without weld, and each brace supports 62 sq. in., the load on each brace is $7500 \div 62 = 120$ lb., which is proved as follows:

The total load to be held by the braces is 745 times 120, equals 89,400 lb. As each brace can sustain 7500 lb., and there are 12, they can hold $12 \times 7500 = 90{,}000$ lb., which is a trifle more than the load they carry.

3. The formula for determining the efficiency of the ligament between the tubes when the holes are drilled diagonal to the axis of the drum is: $(P - d) \div p$.

P = Diagonal pitch of the tubes in this example 6 in.

d = Diameter of the tube = 4 in.

p = Distance longitudinally between the tubes = 5.75 in.

$(6 - 4) \div 5.75 = 0.348$. $0.348 \times 100 = 34.8$ per cent efficiency.

4. See Figure 2.

5. To figure the horsepower of an engine, the well known formula $\frac{PLAN}{33{,}000} =$ hp., will be used.

P = Mean effective pressure per sq. in. on the piston.

L = Length of stroke in feet.

A = Area of the piston.

N = Number of strokes of piston per minute.

Diameter of piston 28 in. Area $= 28 \times 28 \times 0.7854 = 615.75$ sq. in. Length of stroke 60 in. or $60/12 = 5$ ft., and as the revolutions per minute is 75, there are 150 strokes = N.

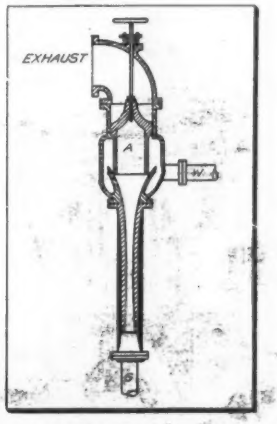


FIG. 4. DIAGRAM OF A SIPHON CONDENSER

The mean effective pressure is not stated so if we use the Massachusetts figure of 50 lb., when rating engines to determine the horsepower for a simple condensing engine, 50 is the value of P.

$50 \times 5 \times 615.75 \times 150 = 23{,}090{,}625$. Divided by $33{,}000 = 699.7$ or 700 hp.

6. See Fig. 3. Much depends upon the extent of the leak. The writer has taken cards from engines in which compression was sufficient for quiet running when exhaust valve leaked.

7. Much depends upon the construction of the valve motion and the speed engine runs. I have succeeded in some cases when the speed was not too high to turn the latch in such a manner as to obtain a larger bite of the hook on the block on the jim crank, caused by the blocks becoming worn until shutting down time came when the blocks were turned.

On another occasion the speed was such and the valve design of such a character the only way to finish the run was to have the oiler hold his finger on the hook, causing it to engage the block and thus lift the valve.

Sometimes the spring can be given more tension to cause the blocks to engage.

8. Briefly described, the siphon condenser consists of a condensing vessel located over 34 ft. above overflow of the hot well and is so placed that the injection water and condensate will run out against the atmosphere without having to be pumped.

The injection water is supplied by a pump or siphoned by the condenser after priming. The exhaust steam enters the top of the condenser, passing down the cone to G, Fig. 4. The injection water enters at W and between the brass cone and the casting.

Water and steam come in contact and cause the steam to be condensed as shown, passing downward through the contracted neck, which consolidates the mass and assists in the removal of the air, acting as a sort of trap to prevent any possibility of air getting up into the condenser from the tail pipe G.

In the jet condenser the injection water and exhaust come in contact and the air pump handles both, discharging them to the atmosphere. A closed vessel, the condenser, is mounted above the air pump to enable the hot water to enter the pump under slight head. The spray usually has a hand wheel located on top to allow of an adjustment of the spray, beside the regular injection valve.

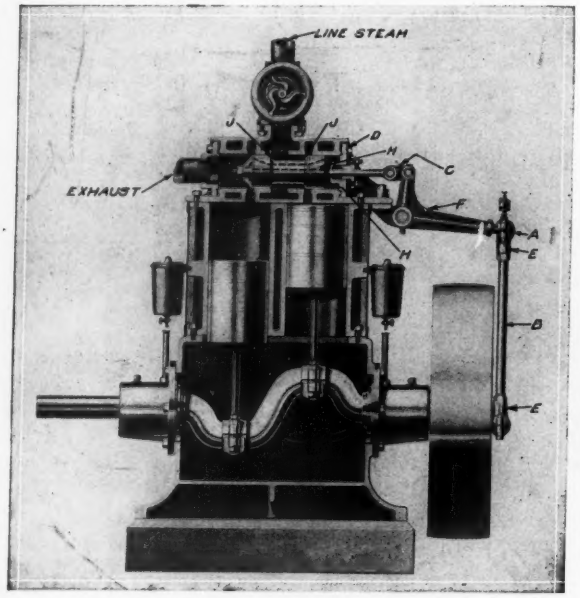


FIG. 5. VALVE GEAR OF WESTINGHOUSE ENGINE

In the surface condenser the construction resembles the straight tube feed-water heater. Usually the circulating water passes through the tube, the exhaust surrounding them. Generally the circulating and air pumps are placed beneath the condenser. The exhaust enters the center of the top of the condenser, which is usually horizontal, surrounds the tubes, then on being condensed, falls to the bottom and thence to the air pump, the circulating pump causing the injection water to pass through the tubes and to final discharge.

9. Thermometers are good indications to many conditions in plants and their use should be more general. The temperature of the hot well as read from a thermometer in comparison to the vacuum carried will tell of a leak, also the speed at which the air pump is run for the load and vacuum carried, will enable the engineer to tell if he has to handle more water than usually provided; the air pump is independent of the circulating pump because if both are driven from same source, change of speed of one would affect the other.

Some surface condensers have water glasses so if any water appears under ordinary operation of the air pump it will point to leaks if the air pump is in good condition. Subject the condenser to a water pressure with the glass watched or maintain the pressure and with the heads removed the tube ends may be watched.

10. The probability is the engine was loaded when the vacuum was lost and the conditions described occur before the load comes on which means that the steam pressure is too high for the friction load or the small load on at the time so that the high pressure cutoff is short and the expansion is high in that cylinder yet not carried to the point where the indicator diagram would loop. If the engine was to run with this small load for any time, reduce the steam pressure or shorten the cutoff on the low-pressure cylinder and not have the high pressure exhaust valve slam.

11. By the sound of the engine, watching the belt, or volt and ammeters if load is electric. Also look at the travel of the valve stem in its guide. A glance at the exhaust head if noncondensing will reveal the character of the load.

12 and 13. The single acting Westinghouse engines, both simple and compound, have 2 cylinders and are provided with a single (one) piston valve.

14. The valve takes steam in the center and exhaust over the ends in the Junior and Standard engines, while in the compound the admission into the high-pressure cylinder is in the center, that cylinder exhausts into the low-pressure cylinder inside of the head and the low-pressure cylinder discharges around the end of the valve.

15. The valve motion of simple pumps is more complicated than that of the duplex type, yet modern designs are simple and more reliable than the older pumps possessed.

Generally the main piston rod moves a rocker bar or tappet which engages the valve stem, moving some form of auxiliary valve, the auxiliary valve uncovering steam ports which allow steam to move the main steam valve, opening communication between the steam chest and cylinder, at the same time permitting the exhaust to pass out. Different builders accomplish the result in different ways.

(To be continued.)

Heating Surface

WILL you please tell me how to figure the heating surface for a closed coil heater to heat 35,000 lb. of water per hour from 40 to 208 deg., the water passing through the coil and the steam on the outside at 4 lb. exhaust steam pressure? I. M. C.

A. The mean temperature of the water is $208 + 40 \div 2 = 124$ deg. At 4 lb. pressure, the temperature of steam is 225.25 deg. F., and the difference between the temperature of the steam and the average temperature of the water is 101.25.

The number of heat units transmitted per square foot of surface per hour, is equal to $101.25 \times 200 = 20{,}250$. Two hundred heat units are transmitted in coil heaters per square foot per hour per each degree difference between the temperature of the steam and the average temperature of the water. You are heating 35,000 lb. of water to a temperature of 208 deg., therefore it will require $35{,}000 \times 208 - 40 = 580{,}000$ heat units. Then the heating surface you will require will be, $580{,}000 \div 20{,}250 = 29.1$ sq. ft. N. G. M.

Problems For Discussion By Readers

What Would You Do If You Had These Conditions To Meet?

Oil in Condenser

I HAVE a surface condenser with 140 ½-in., tinned tubes. The oil inside of the tubes accumulates and reduces the efficiency; the outside or water side is perfectly clean.

What is the best method to remove the oil? Would kerosene oil or an alkali do the work without removing the heads and using a scraper? I should like to hear from the readers. Helos.

Power Plant Questions

I SHOULD like to have the opinion of some of the brother engineers on the following questions; I have my own ideas about them, but may be wrong:

1. How much time should be allowed for an engine to warm up before putting into service?
2. What is the standard way for numbering boilers in a battery, from left to right or from right to left?
3. Is there any practical way for distinguishing the positive from the negative brushes on a direct-current, compound-wound generator?
4. When using a Tirrill voltage regulator, if the resistance is cut in on the generator, it will raise the exciter voltage. What is the cause? W. K. M.

A Criticism

IN your issue of Mar. 1, on page 284, under the head of "Examination for Mine Hoisting Engineers, Springfield, Ill.," I find 2 answers that are not exactly correct.

In No. 7 you say the rope should pass 2½ times around the drum and then be fastened. The mining laws of Illinois state that there shall be at least 3 idle coils on the drum. Again in No. 4 you say, "Six rings or whistles shall call for a reversal of the fan." This is not correct, as there is no signal prescribed by law for the reversal of the fan. But 6 bells or whistles calls for the engineer to hold the cage perfectly still until notified to move it.

R. M. Packingham.

Heater Problem

ANSWERING the inquiry of A. J. in the Mar. 1 issue of Practical Engineer regarding the draining of a heater, I would say, in the first place, I think the way the 1-in. and 2½-in. drip lines are connected to the 3 by 2½ by 1-in. tee, forming a loop, has, when in operation, a tendency to create a partial vacuum.

I would advise putting in a tee in place of an ell at the bottom of the heater just beyond where he now drains it. This will give a more unobstructed flow of condensation. There should be a large enough drip to handle easily the condensation. I would advise leaving the 1-in. drip valve closed, except when needed, as the one drip I propose should be sufficient.

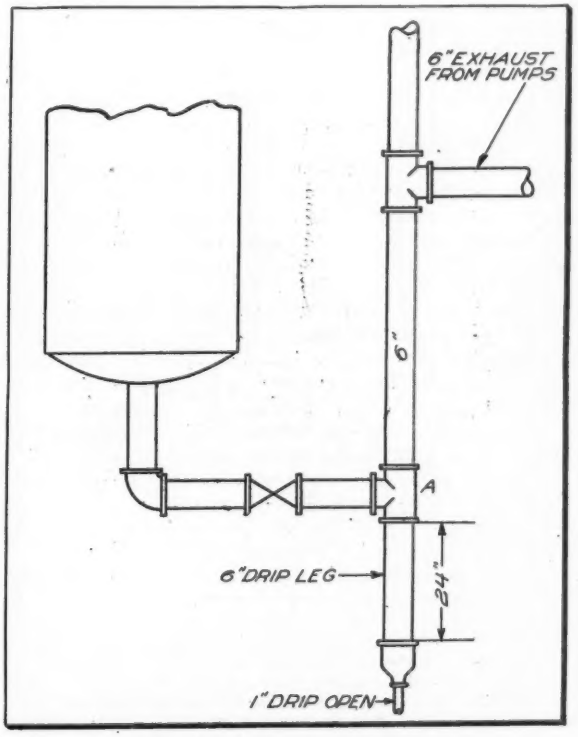
J. H. Norton.

Heater Problem

REFERRING to A. J.'s heater problem on page 286 of the Mar. 1 issue of Practical Engineer, I submit this sketch and explanation.

If you put a 6 by 6 by 6-in. tee at A and a 2-ft. length of 6-in. pipe as shown with an open drip at the bottom you will no doubt overcome your trouble.

The velocity of the exhaust steam is high enough to carry the condensed steam around the elbow in your present piping, because the drip in it is small and at a place where the direction of flow is at right angles to, instead of in the direction of the drip, so the water is carried along with the steam. If you pipe as I suggest, the water, being heavier than the steam, will be shot into the drip leg and drained off by the 1-in. drip. A smaller drip than 1-in. might answer the purpose. Chas. Boardman.



NEW ARRANGEMENT OF PIPING

To REMOVE EXCESS oil from parts of steel tools that have been hardened in oil, place the articles in a small tank of gasoline which when exposed to the air will dry off immediately, allowing the part to be polished and tempered without the confusing and unsightly marks of burnt oil.—Henley.

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CONTENTS

Power Plant Chemistry. Illustrated....347
The Design of Steam Piping Systems. By William F. Fischer....351
Adjusting the Water Supply. By G. H. Brough....354
Power Plant Records. By C. E. Anderson. Illustrated....355
A Study on the Cost of Power....357
Instructions for Firemen. By Asa P. Hyde....358
Regulating Feed Water for Peak and Overloads. Illustrated.360
The Care of Belting....361
Conduit Wiring. By O. N. Casey. Illustrated....362
Protecting Exposed Metal Work in Battery Rooms....363
Electrical Equipment of a Gasoline Automobile. Illustrated..364
Large Electric Project....365
Central Station Vs. Isolated Plant. By J. Case. Illustrated.366
Electrical Correspondence: Synchronous Motors; Electro Magnets. Electrical Engineering Problem. Illustrated..367
Foreign Development in the Power Plant Field. By J. H. Blakey. Illustrated....368
Misdirected Energy. By I. H. P....369
Heavy Modern Gas Engines. Illustrated....370
Gas Engine Data. By Daniel Roesch. Illustrated....371
Combustion Power....373
Correspondence of an Old Engineer and His Son....374
Repairing a Pipe. By H. L. Sherman....375
Letters Direct from the Plant: Trap Wisdom. Lap on Corliss Valve; Stopping a Condensing Engine. Remedy for Belt Trouble. Cleaning Gage Glasses. Indicator Diagrams. The Ohio License Law. Metallic Packing for Pumps. Plant Management. Successful Tank Gage. Cleaning Gage Glasses. Air Compressor Cards for Criticism. Illustrated....376
Successful Kinks from the Plant: Kink for Lathe Workers. Babbiting a Crosshead Shoe. Home-Made Hydraulic Pump. Illustrated....381
Questions Answered and for Answer: Answers to Massachusetts Examination Questions for First Class License. Heating Surface. Illustrated....382
Problems for Discussion by Readers: Oil in Condenser. Power Plant Questions. A Criticism. Heater Problem. Illustrated....385
Editorial: The Engineer's Part in Law-Making....386
Acceptance Test of Large High-Vacuum Condenser. Illustrated....388
Unions for Gage Glasses and Pipe. Illustrated....390
Society of Superintending Engineers....390
News Notes....390
Book Review....391
Catalog Notes....391

THE ENGINEER'S PART IN LAW-MAKING

This refers not only to the laws as made by our legislatures and by Congress, but to the local legislation which we ordinarily speak of as city and town ordinances, for perhaps in the latter lies a greater field for usefulness of the engineer who knows about technical matters.

The great lack of understanding of the layman in regard to engineering facts and laws is evidenced very much in newspaper articles and in court trials, where the twisting and distortion of facts is ludicrous to one who is familiar with engineering matters. This is not to be wondered at, for engineering is a special and specialized calling, and it is doubtful if most engineers would show any better knowledge of the points of law or the facts of astronomy or medicine, than do newspaper men and lawyers of the facts of engineering. Nevertheless, to take intelligent action on proposed laws and ordinances dealing with engineering matters, the public official, be he lawyer or manufacturer, must from some source get an intelligent understanding of the business in hand, and this understanding he can get only from engineers who know. It becomes, therefore, the duty of engineers to furnish this information in their own interest and that of the community.

In municipal affairs especially, it is a favored plan for an expert to be employed to report to a committee, but a single expert is human and is likely to have bias in his opinions—a fact which is recognized by the members of the committee, who usually discount the opinions of their hired expert to the point of absolutely disputing his conclusions. Facts and opinions which are backed by a large body of men of expert knowledge are, however, not liable to such summary treatment, and are always welcomed by fairminded public officials who are after the truth.

Probably the 2 most vital matters of interest to operating engineers are license laws and rates for electric currents. When license laws come up for consideration, there is always interest manifested by the public press and by employers, and the opinions expressed by the editors of the newspapers are apt to carry much weight with the public at large, as much as with those charged with the duty of law making.

A recent example of what may happen comes from Trenton, N. J., where a bill is before the New Jersey legislature authorizing the passage of ordinances by the governing bodies of cities and towns in that state, to provide for examination and certificate of stationary and portable engineers. The usual exemptions are made of boilers and engines under control of the United States, of the railroads, city fire departments, and heating plants carrying pressure of not more than 10 lb. In an editorial, one of the Trenton papers questions why these exceptions have been made, and characterizes the entire attempt as an effort to "add another to the trade monopolies." The entire editorial was based on a misunderstanding of the conditions. It opposes the bill and concludes that "When one recalls the fact that there are exceedingly few accidents reported as the result of carelessness or inefficiency on the part of stationary engineers and firemen, he must be convinced that there is little need of examinations and licenses for the very simple work of running a stationary boiler or engine."

It would be interesting to place the writer of this editorial in one of our modern power plants, equipped

with high-pressure boilers, mechanical stokers, Corliss engines, low-pressure turbines and alternating-current machinery, and let him undertake the "very simple" running of this plant. After a few hours of experience, he might conclude that it was desirable to have someone of expert knowledge and efficiency to be responsible for this work. But the editorial was printed, and the opinion of many readers influenced by it.

In this case, the editorial was promptly answered by Harry H. Yates, who furnished us the information, and by James R. Coe, of New York City, who pointed out quite plainly the reason for the exemptions in the bill, the need of having trained men in charge, and the fact that accidents are not so rare as the editor thought, and are frequently disastrous to life and property. The editor was fair enough to give these communications prominent space, and to the regular reader of the paper they would correct the wrong impression; but it would have been much simpler if the editor had been well informed in the first place, so that his editorial might have had the basis of correct information, even if his opinion was still opposed to the license law.

It is evident, therefore, that engineers must make it their business to see that all who have influence in the passing of laws are properly informed on these points, and a campaign for a license law should take in not only the legislators, but the newspaper editors.

On the second point—central station rates—the problem is more difficult, because of the question of vested interests, and just how far a public utility corporation may be regulated. The facts show that in many instances the rates quoted are based on a policy of "get the business," rather than cost of producing the current or a fair return on the investment. A low rate for current supplied during the light load period only can be justified on the basis that such current is really a by-product of the plant, and if the charge for it brings back the cost of labor, fuel, supplies and distribution, with a reasonable profit, it is satisfactory, since the plant and equipment must be maintained to supply the peak load. Such a low rate cannot, however, be justified if the current supplied at that rate laps over onto the heavy load period of the station, for extra generating capacity must then be installed to take care of this low rate load. Current sold in large quantity to a single customer can also fairly be sold at less than the same amount of current supplied to a number of small users, because the distribution cost is less, although the manufacturing cost, which should always include the overhead charges, will be the same whether the current be distributed from the switchboard to many small customers or to a single large customer. In any case, there is no justice in selling current to large consumers at less than cost, and making up the loss by charging an excessive rate for current supplied in small quantities, for either power or lighting. These points should be strongly emphasized and the facts placed before the public, the press and the law-making bodies..

An instance in hand is the station at Tacoma, Wash. There is rivalry between a private company and the municipal plant, and the public officials are proposing to supply current at a rate of less than one-half cent a kilowatt-hour. Superintendent Thorn of the city plant has given the following table as showing the cost and selling price per kilowatt-hour for various annual load factors:

Per Cent Load Factor	—Cost— Steam Plant	Water Plant	Selling Price for Water
15	1.54	1.52	2.44
25	1.12	0.91	1.46
33	0.97	0.69	1.10
40	0.89	0.57	0.92
50	0.81	0.46	0.73
60	0.76	0.38	0.61
75	0.71	0.31	0.49

The costs given are evidently those at the switchboard, and include depreciation, interest on the money invested and operating expenses, but do not include distribution costs, and it is difficult to see how the selling prices given can be quoted after including the distribution cost. The values are based on the assumption of a fixed annual charge of $13 per kilowatt plus an output charge of 5 per cent per kilowatt-hour for the steam plant, and a fixed charge of $20 per kilowatt of demand on water power plant. The selling price is stated to give a profit of 6 per cent on the investment.

The engineers of Tacoma have taken up the matter and have shown that in a large number of plants in the city, even the low rate proposed will not affect their plants, as the current is a by-product of the heating system and of the steam used for industrial purposes, and costs the manufacturer less than would purchased current even at the low rates proposed. But the commission in Tacoma has refused to receive the evidence of the engineers, and they have gone into the newspapers of the city to state their case and give their facts. This is the logical and reasonable way to handle it, because it will educate the public in the matter and will bring public opinion to bear on the law makers. The estimate of the engineers is, that including the cost of distribution current cannot be sold at less than 1¼ cents per kilowatt-hour and pay expenses, and this figure will fairly well agree with the facts from other cities.

Another injustice in this particular case is the furnishing of tungsten lamps free to large consumers, while small consumers are compelled to pay for them. It is just such unfair conditions as this that engineers should make it their business to combat and overcome if possible. Facts and figures must be put in such form that the layman can understand them, and the most easily understood form is that of dollars and cents, of cost and reasonable selling price.

Co-operation with others than engineers must, of course, be secured, so as to remove any charge of class prejudice or class interest, but the owners, manufacturers and superintendents are frequently not in position to give the necessary information, and this part of the work must be done by the engineer.

WARNING

A NUMBER of complaints have come to the Publishers of Practical Engineer from northern Ohio and Indiana that a party signing himself C. F. Woods has offered Practical Engineer at 75 cents and $1.00 per year, including premiums. This man is an imposter and we are desirous of locating him. We ask any engineer to wire us information immediately at our expense, should he make an attempt to solicit.

Do not give a subscription or pay money to any one who is unknown to you or who can not show a letter of authority from us. All our agents carry proper credentials, except local agents working among their own friends or acquaintances.

Power Apparatus in Shop and Market

New Ideas In Making, Buying and Selling

ACCEPTANCE TEST OF LARGE HIGH-VACUUM CONDENSER

THE data given below are from tests on a condenser of the dry tube base design, manufactured by the Wheeler Condenser & Engineering Co., Carteret, New Jersey, installed at the South Works of the Illinois Steel Co., South Chicago, Illinois, in connection with a 7000-kw. Curtis mixed pressure turbo-generator.

Low-pressure steam is supplied by 3 2000-kw. compound reciprocating engines, which discharge into a header about 100 ft. long. In addition to this supply of steam, the exhaust from blast furnace blowing engines and auxiliaries is used up to a capacity of 200,000 to 250,000 lb. an hour. High-pressure steam is used to carry the load in case of a deficiency in the supply of exhaust.

The arrangement of condenser and auxiliaries is shown in Fig. 1. The condenser tube surface is arranged in 2 sets of banks on either side of the center line with dry plates at several elevations on each side draining outward towards the shell. They divide the tube surface into a number of compartments, designed to give the most efficient and even distribution of the steam to all of the surface.

There are about 6000 1-in. tubes making in all about 25,000 sq. ft. of surface. The circulating water makes 2 passes through the tubes entering at one end and passing through the lower bank of tubes on both sides of the center, returning through the top bank to the discharge.

The circulating water is drawn from Lake Michigan through an intake tunnel 150 ft. long and discharged to a sewer. The circulating pump (Fig. 3) is a Wheeler 36-in. double suction volute pump, operating at a speed of from 100 to 135 r.p.m., driven

FIG. 3. CIRCULATING PUMP

by a 20 by 24-in. Cooper Corliss engine, which may be seen in the background of the photograph. The dry air pump is a 14 by 36 by 24-in. Wheeler tandem

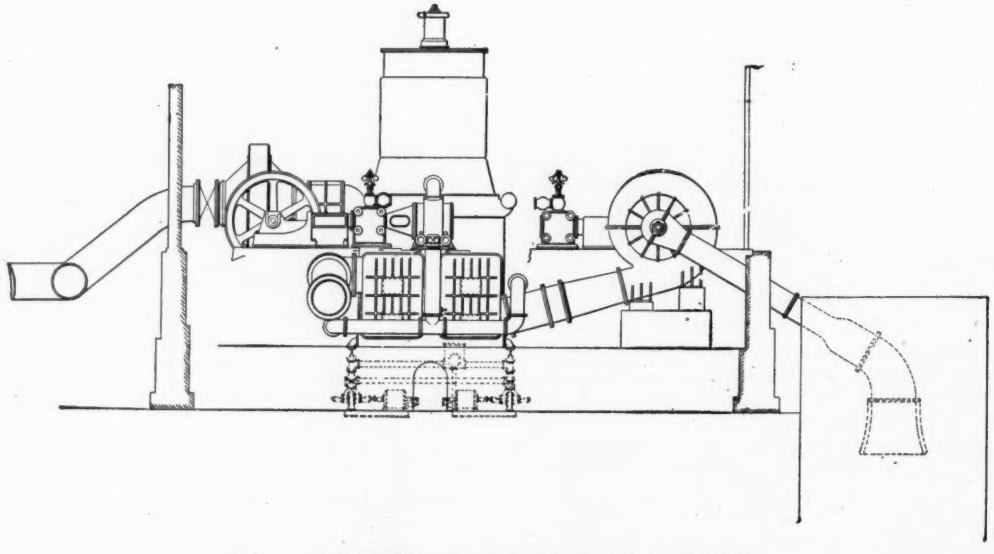


FIG. 1. ARRANGEMENT OF CONDENSER AND AUXILIARIES

rotative dry vacuum pump and has shown remarkable efficiency, as indicated by the tests. Two 5-in. centrifugal hot well pumps are installed, driven by 24-hp. steam turbines.

Guaranteed Performance and Results of Tests

THE following vacuums were guaranteed with temperature of cooling water 70 deg. F., and the quantity of water, not more than 34,000 gal. a minute.

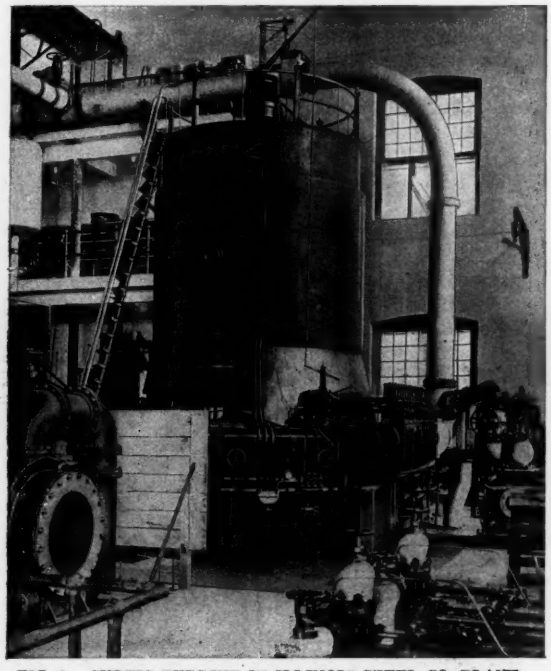


FIG. 2. CURTIS TURBINE IN ILLINOIS STEEL CO. PLANT

Vacuum	Load in lb. of Steam per Hour
28.3	210,000
28.5	185,000
28.6	150,000
28.7	120,000
28.9	70,000

Tests were made by the steam engineering department of the Illinois Steel Co., to check the guaranteed

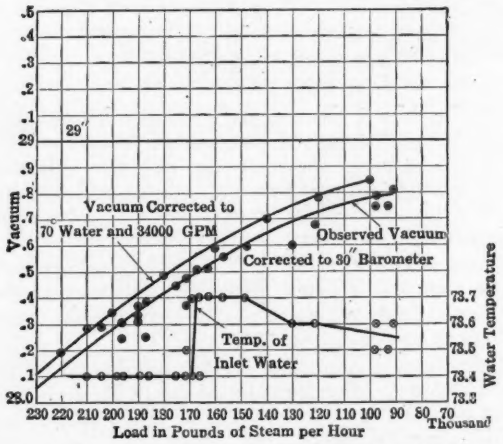


FIG. 5. RESULTS OF CONDENSER TESTS

values. The tests were made in July with inlet circulating water at 73.4 to 73.7 deg. F. In calculating the final results, the performance was corrected to 70 deg. water and a smooth curve drawn between vacuum and load is given in the chart of Fig. 5. The same chart also gives the actual vacuums with the water averaging about 73.6 deg. F.

Referring to Fig. 5, it will be noted high vacuums are obtained with cooling water at 73½ deg. temperature.

The difference in temperature between the discharged condensing water and the steam ranged from 4 to 10 deg. during the test and the hot well temperature ranged only 2 to 6 deg. below steam tempera-

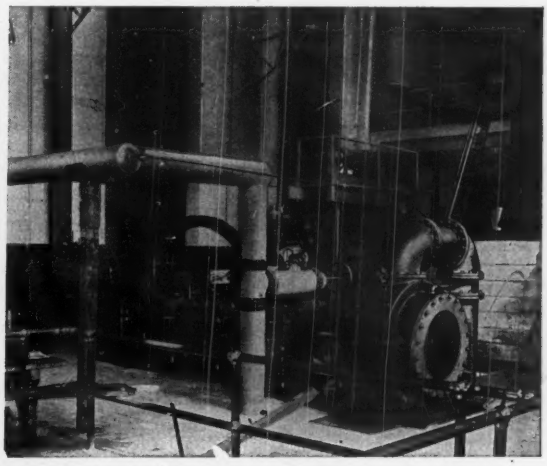


FIG. 4. TANDEM ROTATIVE DRY VACUUM PUMP

ture. The high coefficient of heat transmission was 550 B.t.u. per sq. ft. per hour per degree difference in temperature with a load of 210,000 lb. of steam per hour.

The greatest load on the condenser was 210,000 lb. of steam per hour, but it is evident from the test that a load of 250,000 lb. of steam per hour would have carried with 28-in. vacuum and 70 deg. water. This is equivalent to 10 lb. of steam per sq. ft of surface, and under these conditions, the coefficient of heat transmission would have been about 600.

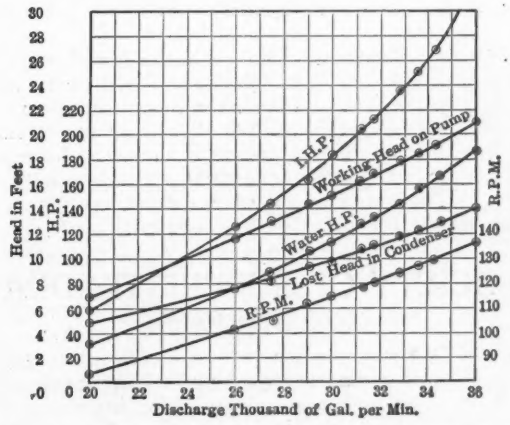


FIG. 6. RESULTS OF TESTS OF CENTRIFUGAL CIRCULATING PUMP

The coefficients of heat transmission are calculated on the basis of 980 B.t.u. per pound of condensate, and by the logarithmic formula for heat transmission.

The test on the Wheeler dry vacuum pump showed an average mechanical efficiency of 83.9 per cent which is remarkably high. The test on the centrifugal circulating pump is covered by the chart of Fig. 6.

UNIONS FOR GAGE GLASSES AND PIPE

MAKING a joint in a gage glass is a distinctive novelty, but occasions arise where such a joint is desirable when a long glass breaks and sufficient tube is not on hand to put in a new one, or in the case of a glass which is giving trouble to provide for expansion. The union shown in Fig. 1, the Jones universal union, made by W. A. Jones, of Toledo, O., provides a means for accomplishing this. The construction and action are clearly shown in the illustration.

The union joins the 2 ends of the gage glass or small pipe, and permits of a quick joint without the cutting of threads on pipe, also permits of an expansion joint and of joining 2 ends which may be slightly out of line, the packing in the union making the joint against the ends of the pipe or glass. These unions are made up of brass when used for gage glasses, and for pipe from ¼ to 1¼ in., are of malleable iron. The packing used is candle wick for water and asbestos for steam. The unions are tested to stand a pressure of 300 lb. per square inch.

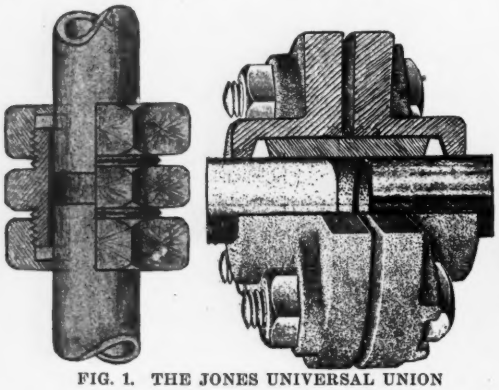


FIG. 1. THE JONES UNIVERSAL UNION

FIG. 2. JONES FLANGED UNION FOR USE WITHOUT THREADING

Figure 2 illustrates a flange union for pipes ½-in. and larger, also tested to 300 lb., and packed the same as the smaller sizes. They have been used over long periods in lines carrying 120 lb. of steam or water pressure. They are also made in shape to be put in radiator coils in place of the right and left-hand couplings. The convenience of these unions for many places about the plant will be obvious.

SOCIETY OF SUPERINTENDING ENGINEERS

A NEW organization of engineers was recently formed in Boston by a number of prominent men in the engineering field. The organization is called the "New England Society of Superintending Engineers," and is composed of chief engineers, superintendents and master mechanics who have charge of large power plants.

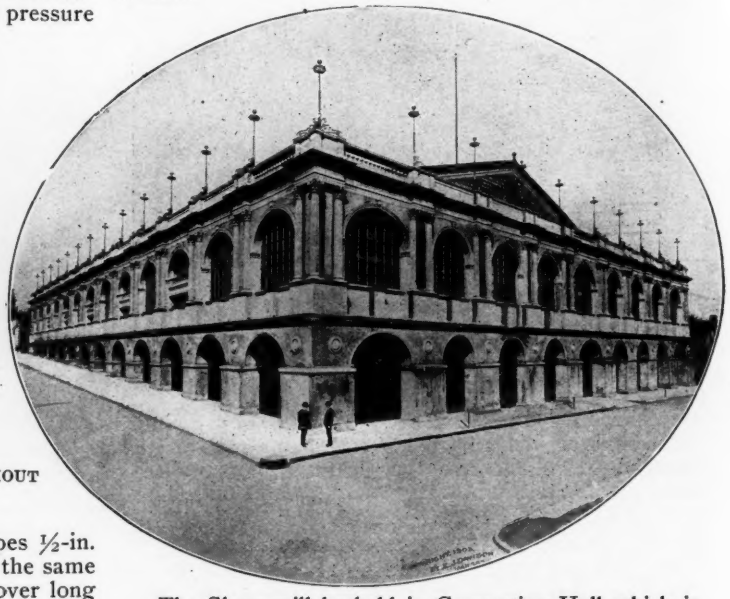
The objects of the society are:—To promote knowledge on all matters relative to the construction, operation and management of large power plants and their equipment, which may be brought before the society for consideration and discussion. To encourage social relations among its members. To aid each other either personally or professionally and assist each other in a practical way in any matter affecting the members.

The membership is limited to men who, at the time of making application, shall have actual charge or direct supervision of steam plants of not less than 2000 hp.

The officers are:—President, George W. Walsh, Chief Engineer Central Power Station, Boston Elevated Ry. Co., Boston, Mass.; Vice-President, L. H. Brown, Chief Engineer Lynn Power Station, Bay State Street Ry. Co., Lynn, Mass.; Secretary-Treasurer, F. L. Fairbanks, Chief Engineer Quincy Market Cold Storage Co., 69 Eastern Ave., Boston, Mass.

NEWS NOTES

MESSRS. Parker, Lauson, White, Knoblock and Stritmatter, members of the Show Committee, National Gas Engine Association, met at the La Salle Hotel, Chicago, Feb. 15, and decided to hold the Second Annual Gas Engine Show at Kansas City, Mo., August 16 to 23, inclusive.



The Show will be held in Convention Hall which is adapted for the holding of shows of this character. Provision will be made for about 200 exhibits. Plans and contracts are being prepared and will be mailed to prospective exhibitors within the next 30 days. Members of the association will have the first choice of space.

CUMBERLAND CAPITAL will erect a $100,000 hydro-electric plant on the South Branch of the Potomac river, near Springfield, W. Va., to supply commercial current to Romney and Springfield.

THE MONASH-YOUNKER Co. has recently added to its force George A. Muir, recently of the D. H. Burnham & Co. office. Mr. Muir is well known to the heating trade as a Heating Engineer.

THE ANNUAL MEETING of the stockholders of The Goulds Mfg. Co. was held at Seneca Falls, N. Y., Feb. 24. No change was made in the board of directors and the following officers were re-elected: President, N. J. Gould; Vice Presidents, D. V. Colby, W. D. Pomeroy, W. E. Davis, W. E. Dickey; Secretary, H. S. Fredenburg; Treasurer, B. R. Wells; Assistant Treasurer, E. W. Medden.

BOOK REVIEW

THE A B C OF THE DIFFERENTIAL CALCULUS by Wm. Dyson Wansbrough, 5 by 7 in., 148 pages, bound in cloth, price $1.25. In this book no attempt is made to compete with any existing work on calculus. The aim on part of the author has been to provide a ladder by which to reach the comparatively elevated platform which forms the starting point for most of the recognized standard textbooks on the subject.

BULLETIN No. 61, "Characteristics and Limitations of the Series Transformer," by H. R. Woodrow and A. R. Anderson, has just been issued by the Engineering Experiment Station of the University of Illinois. This bulletin presents the results of a theoretical investigation of the characteristics and limitations of the series transformers more particularly in connection with its use in recording transient currents.

Copies of Bulletin No. 61 may be obtained upon application to W. F. M. Goss, Director of the Engineering Experiment Station, University of Illinois, Urbana, Illinois.

PERKINS' TABLES; For Use in Calculations of Safe Working Pressure on Boilers. By Lyman B. Perkins, 361 pages, on thin paper, in flexible leather binding, Hartford, Conn., 1912.

This book will be found invaluable to boiler inspectors, designers and manufacturers, who have a large number of calculations to make in regard to boiler strengths. The tables have been arranged to give the safe working pressure for a shell with practically any type of riveting, for the head with any form of bracing, and for the furnace with any kind of staying, all with practically no computation. The directions for use of these tables are clear and simple and fully illustrated by examples, and with formulas to cover such cases as cannot be found in the tables proper. The completeness can be seen for instance from the tables for bursting pressures of hollow cylinders. These are given for boiler plate from ¼ in. up to ¾ in., by thirty seconds, and from 26 in. in diameter up to 96 in. in diameter, all common diameters in use being given; the tensile strengths shown are from 45,000 up to 62,000 lb. per square inch. Other values are treated with like fullness. The important subject of joints, both lap and butt strap, in single riveted, double riveted, triple riveted and quadruple riveted, is covered so fully that it takes up nearly 300 pages of fine print. Besides the general calculations, a full table of calculations, in order to meet the Massachusetts, Michigan and Ohio standards, is given, and the entire book is indexed alphabetically, so that all values are quickly found.

CATALOG NOTES

SUPERHEATING is the title of a 16-page pamphlet published by the Heine Safety Boiler Co. The first part of the pamphlet is a reprint of a paper from the Journal of the Engineers' Society of Pa., discussing the steam and fuel economy of superheating the various designs of superheaters, the methods used for obtaining control of the temperature of superheat, and a brief description of the design and operation of the Heine superheater. The Heine superheater is installed to the side of the main boiler drum in a superheater chamber forming a part of the main boiler setting. The superheater chamber connects with the furnace by a flue through which a small percentage of the furnace gases flow. A damper at the outlet of the superheater controls the volume of gases and therefore the superheat temperature. A chart is reproduced which shows the performance of a Heine Superheater illustrating how the steam temperature is maintained within about 5 deg. of the mean. The last part of the pamphlet is devoted to abstract from the Transactions of the American Society of Mechanical Engineers on the effect of superheated steam on cast iron. Copies will be sent to engineers on request to the Heine Safety Boiler Co., St. Louis, Mo.

GOETZE GASKET & PACKING CO., of New Brunswick, N. J., is sending out an illustrated circular with price list of Goetze gaskets and packings.

BEANDRY POWER HAMMERS, built in 2 types and a wide range of sizes, are described in a pamphlet from Beandry & Co., of Boston, Mass.

A. S. CAMERON Steam Pump Works, 11 Broadway, N. Y., is distributing a 48-page booklet on steam pumps. In addition to the lists of sizes, illustrations and descriptions there is much other useful information that will be of value to operating engineers. A copy will be mailed on request.

CLING-SURFACE TREATMENT FOR ROPES is the title of a bulletin just published by the Cling-Surface Company, Buffalo, N. Y. This bulletin shows a number of noteworthy treated rope drives, gives technical data, and carefully describes them all. A copy will be mailed on request.

THE CHAPMAN VALVE MFG. CO., of Indian Orchard, Mass., has just issued a circular describing its brass gate valve. Accompanying the circular is a standard list, adopted by valve manufacturers in 1911, of iron body bronze mounted gate valves; this is to be inserted in the company's Catalog No. 30.

BULLETIN No. 4085, just issued by the General Electric Co., describes more or less briefly that company's battery-charging motor-generator sets for railway signaling. The bulletin should be of service to railway men.

Bulletin A4083, from the same company, is devoted to the subject of US-13 roller bearing trolley bases, and supersedes the company's previous bulletin on this subject.

THE GENERAL ELECTRIC CO. has just issued an interesting bulletin (No. A4080) devoted to the use of electricity in excavation and construction work. The bulletin deals with both the generating of the current and its use through motors. It touches on the advantages to be derived from the use of electric power, and refers briefly to its application to the work in connection with the Panama Canal, Catskill Aqueduct, New York Barge Canal, and in general building construction.

A QUARTET is the subject of a folder from James McCrea & Co., 558-560 Washington Blvd., Chicago. It consists of a steam-joint clamp, a pipe clamp, a valve-reseating tool and a bibb-reseater.

SIGHT UNSEEN is the title of a circular relating to Kewanee pipe unions. Each union is subjected to a rigid test which, it is asserted, defective unions cannot stand. The circular is issued by the National Tube Co., of Pittsburgh.

FOSTER VALVE SPECIALITIES are discussed in Catalog 20 from Foster Engineering Co., Newark, N. J. The catalog contains 112 pages, giving some general information about pressure regulators and kindred devices, describing and illustrating many types of valves.

PRACTICAL ENGINEER

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POSITION WANTED—By Chief Engineer. 20 years in charge of large power plants. Thorough knowledge of steam, electrical, hydraulic and refrigerating machinery. Life study of scientific management. Total abstainer. W. F. Bonsman, 945 Front Ave., Grand Rapids, Mich. 4-1-1

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POSITION WANTED—By middle aged man as engineer. Holds 2nd class Massachusetts License. Have had experience in electric light and power plants. Will go anywhere. Present position four years. Total abstainer. Can give best of references. Address R. W. Plummer, 39 Norcross St., Lowell, Mass. 4-1-1

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POSITION WANTED—As chief engineer, age 31; married, understands electric machine, mechanical drawing, first class Ohio license; can give reference. Wages depend on the cost of living at that place. Address, Box, 1292, Practical Engineer. 4-1-1

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POSITION WANTED—By married man of 25, college graduate, with 5 years' experience in electric light and power plants. My present position expires May 1st. Can furnish best of references, and can get results. State salary, and nature of work in first letter. Ezra D. Dumas, Stillwater, Okla. 4-1-1

POSITION WANTED—As engineer or switch-board operator in large station. Have eight years experience in power station with high and low speed engines. Direct and alternating current generators. Prefer middle or western states. Address Box 293, Practical Engineer, Chicago, Ill. 4-1-1

POSITION WANTED—By first class Ohio Licensed Stationary Engineer; 15 years experience. Wishes position as chief engineer in steam power of large building or steam electric power plant; best of references; married man; 31 yrs. of age. Wm. Wisely, 1318 Yondota St., E. Toledo, Ohio 4-1-1

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WANTED—AGENTS TO SELL on commission Mechanical Draft Blowers. Prefer men who handle on similar bases sales of grate bars, tube cleaners or other boiler accessories. Hustlers wanted. State experience and territory worked. Address Box 290 Practical Engineer, Chicago, Ill. tf.

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WANTED—ALL STEAM USERS to have clean boilers without using compounds or chemicals in any form. Write "Otis," No. 317 Norfolk Ave., Buffalo, N. Y. tf.

WANTED—SALESMEN calling on firms with stationary engineers, to write us for desirable open territory, where they can soon build up permanent business with our guaranteed product insuring repeat orders. Address 322 Real Estate Trust Bldg., Phila., Pa. 2-15-24

IF YOU ARE a night engineer, spend a few hours each day taking subscriptions for Practical Engineer. You will be paid well. Write Subscription Dept. They will start you in at once. tf.

WANTED EVERY ENGINEER to have our pamphlet for setting valves on Corliss Engines, simple and compound, with one or two eccentrics. Sent free. Lindstrom's Machine Works, 200 South Third St., Allentown, Pa. tf.

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WANTED—By a Power Plant Equipment Manufacturing concern, a Sales Manager, having technical education, practical motive power experience, and demonstrated capacity for organization, correspondence and sales getting. Address in confidence with full particulars, including salary expected. Box 294, Practical Engineer, Chicago, Ill. 4-1-1

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FOR SALE—ONE 14 by 36 Standard Murray Corliss Engine, 12 ft. wheel. One 75 kw. 250 volt D. C. Westinghouse Generator, speed 725, two wire. One Westinghouse D. C. Balancing Set, capacity 60 neutral amperes, 110 volt. One 74 ft. double leather belt, 20 in. wide. One switchboard with instruments. Two 54 14 Tubular Boilers complete with rocking grates. One Gardner duplex feed pump, 3 by 4 by 2½. One Open Feed Water Heater. This machinery is in first class operating condition. In shape for inspection. Madrid Electric Light & Power Co., Madrid, Iowa.

FOR SALE—22x48 Brown Corliss Engine wheel 16x27 ft., left hand. Condition like new. $800.00. Duzets & Son, Hudson Terminal, New York.

TWO 175 HP. MANNING BOILERS butt jointed; 125 lbs. pressure, splendid condition. $1000 for the two. 20x42-inch Harris Corliss Engine 16 ft. wheel guaranteed—$800. 14x26x16-inch Harrisburg Cross Compound Engine—$800. 800 H. P. draft outfit—$450. J. F. Foster, 166 Devonshire St., Boston, Mass. 4-1-2

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FOR SALE—A 32 H. P. HORNSBY-AKROYD Oil Engine with starting device, in very good condition; also a 15-ton Challoner refrigerating machine, oil separator, double pipe ammonia condenser and high and low pressure gauges. These are also in good condition. For particulars inquire of the Rahr Br'g Co., Oshkosh, Wis. 1-1-6

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IF YOU ARE an operating engineer, we know the Fetta Hot Process Water purifier will interest you. We would be glad to have your request for further information. Address the Fetta Water Softener Co., Richmond, Ind. tf.

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Suppose, sir, that you had to order certain equipment for your engine room today—that you had to do it quickly without taking any time to investigate?

Would your purchase be tangible evidence to your employer that you were of additional value to him because you possessed the knowledge which enabled you to buy wisely? Are you taking care to educate yourself along such lines?

In almost every business the buyer is a big man—a man who draws a big salary. He draws a big salary because he has made himself of exceptional value to his firm. And he has made himself of exceptional value to his firm by becoming thoroughly familiar with those things which his firm buys. This knowledge which he possesses makes him exceptionally valuable because it enables him to buy with discrimination, getting the greatest ultimate value in each instance.

Now, Mr. Reader, apply this to your own case.

Are you valuable to your firm because of your ability to buy wisely? If you had to order something quickly—right now—could you do so, feeling that your broad knowledge of power plant equipment would enable you to order that which would prove the most valuable in the end? Have you looked through the advertising section of this issue of "Practical Engineer" to see what there is there that you will want to investigate?

Practical Engineer's advertisers are the leading manufacturers of power plant equipment, and the selling agents of the best inventions. Its advertising section is practically an encyclopedia of all that is modern in the power plant field. Probably, somewhere among its pages is information about a machine or an appliance which you could use advantageously in your plant or factory.

That's one of the advantages which advertising brings to you. It makes it easy for you to gather this buying data—to familiarize yourself with the good points of the various products so that you may decide intelligently which would most efficiently fill the requirements of your plant.

The fact that a product is advertised consistently is, of course, good evidence of that product's reliability. But only one of two or three or four thoroughly meritorious products might prove to be the wisest choice for the conditions in your plant. Hence by studying the various points which are brought out in the advertisements you are enabled to discriminate and choose accordingly.

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